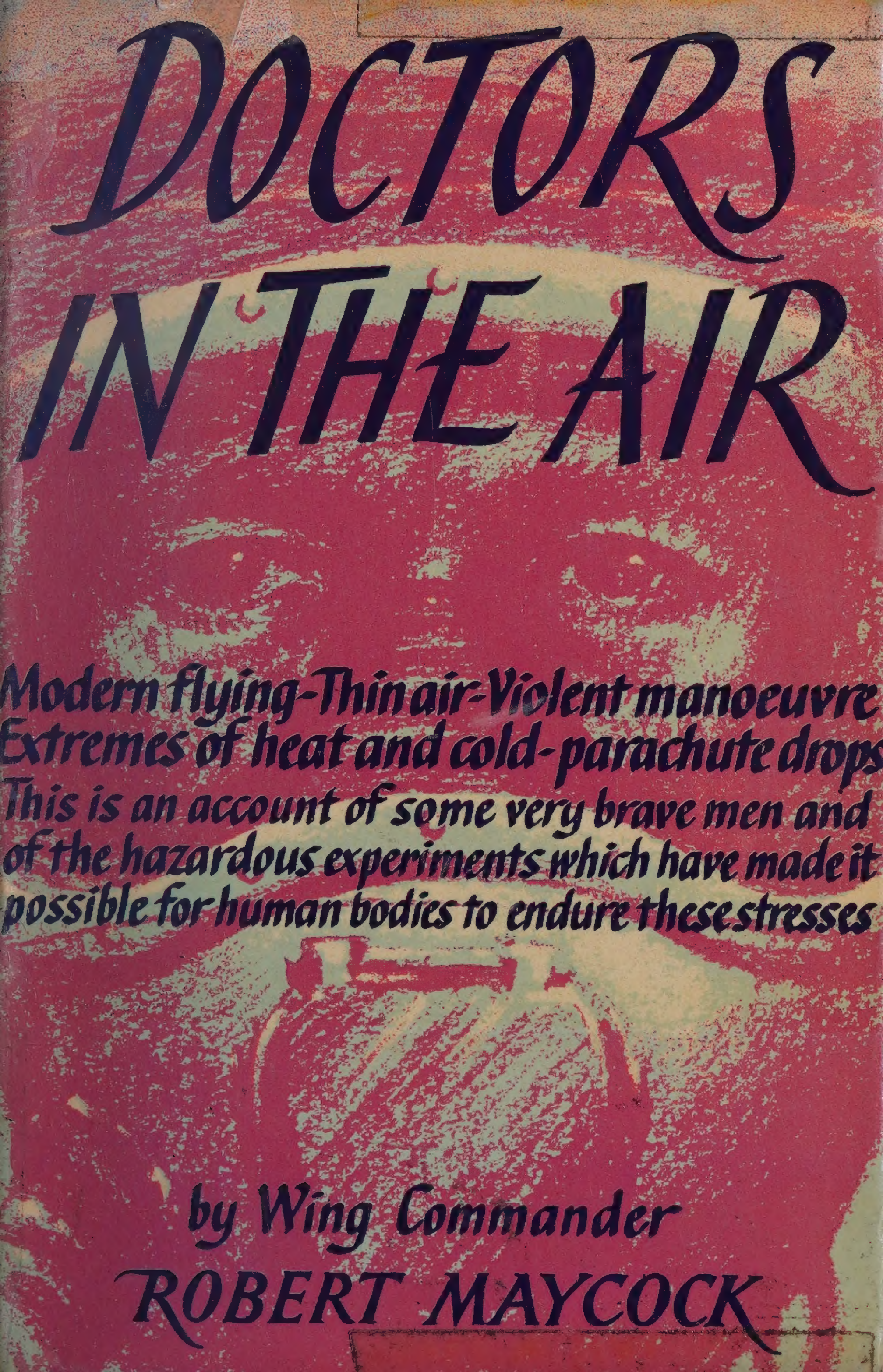

DOCTORS IN THE AIR

Modern flying-Thin air-Violent manoeuvre
Extremes of heat and cold-parachute drops
This is an account of some very brave men and
of the hazardous experiments which have made it
possible for human bodies to endure these stresses

by Wing Commander
ROBERT MAYCOCK

Doctors in the Air

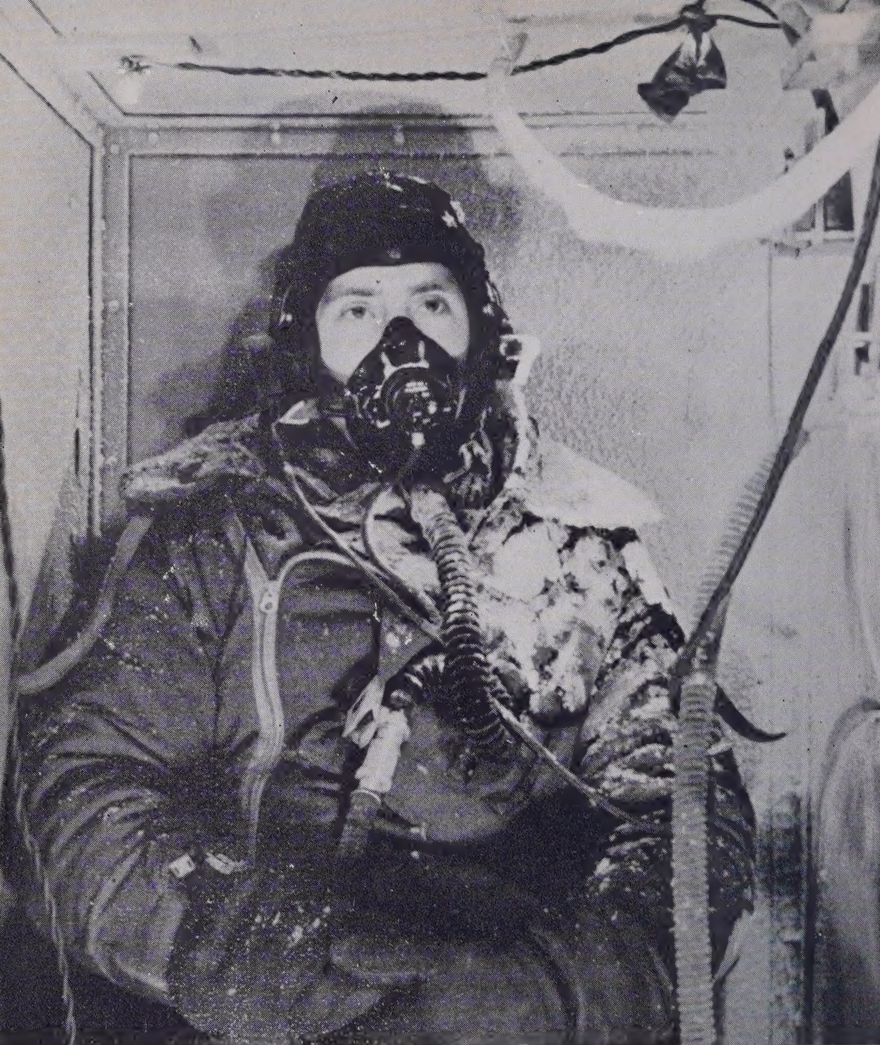

PLATE 1
BELOW ZERO. *Testing clothing and oxygen equipment in a cold chamber.*

Doctors in the Air

By

Wing Commander
Robert Maycock
A. F. C.

London
George Allen & Unwin Ltd
Ruskin House Museum Street

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Introduction

TWO incidents in the air, separated in time by nearly twenty years, serve to show one of the reasons why there should be doctors in the air. The first concerns Flight Lieutenant George Stainforth, a skilled test pilot and a public figure of his day after winning the Schneider Trophy. One day some little time before the war he was flight testing a prototype Spitfire. He had taken off from Boscombe Down in Wiltshire. The weather was clear and fine, the aircraft in good shape and giving evidence of the power which the enemy found such a menace in its long line of successors. As it climbed steadily toward the blue summer sky there seemed to be no reason why this flight should not be quite uneventful. At a height, estimated at somewhere over 20,000 feet, the picture changed with dramatic suddenness. From the ground the aircraft was seen to go from the climb into a vertical dive and then tear towards the earth. It appeared to be completely out of control and, with full power still on, it did not seem possible that the pilot could pull out in time, but gradually the dive flattened out and the aircraft was brought into level flight. The recovery was probably due to Stainforth's great physical strength. After he had landed it was found that the centrifugal force imposed on the aircraft during the pull out of the power dive had been so high that the wings had been wrenched, or 'set back' three or four inches out their true line.

The second incident occurred only recently and involved the pilot and navigator of a night fighter Venom. They also took off on a day trip in equally fine weather and with a sound aircraft. This flight also should have been uneventful. The Venom climbed smoothly away and much sooner than the prototype Spitfire was well above 20,000 feet. The navigator suddenly noticed that his pilot's behaviour was strange and his flying not up to his usual standard. He asked if he felt all right. 'Yes, fine.' At 30,000 feet it was certain that all was not well. The pilot was obviously ill and was losing control. The navigator leaned over, closed the throttle and lowering the dive brakes repeated in a loud clear voice, 'Go down! Go down!' When they had descended below 20,000 feet the pilot recovered a little and his flying and behaviour once again became normal. On being given a course to steer for base he called up on his radio that he was not completing the sortie as there was something wrong with his navigator!

The cause of both these near tragedies was the same; lack of oxygen. Stainforth, flying without an oxygen supply, was probably tempted by the clear summer sky and the brilliant sunshine to climb higher than was wise. The Venom pilot found after he had landed that the oxygen supply to his mask was not properly connected. One lost control of his aircraft completely and nearly crashed, while the other showed all the symptoms of those who venture into the 'thin' air of great heights without any protection. These symptoms are first, an over-confidence and feeling of well being, and later fumbling and mental confusion, which persists even at a lower and safer level, so much so that the Venom pilot was convinced that it was his navigator and not he, who was behaving queerly.

This lack of oxygen, or anoxia, is just one of the sicknesses that can afflict those who venture into high places whether on a mountain, in balloons, or in aircraft. Aviation medicine is in the truest sense preventive rather than curative. Its perennial concern is to protect aircrew by training, indoctrination and the development of protective equipment against all the hazards that they must face. Speed, height, violent acceleration and deceleration, heat, cold, fatigue and noise; all these and many more problems are the concern of the workers in aviation medicine. To assess the scope of a problem doctors have, and will continue, to experiment on themselves in laboratories, in the field and in aircraft. They become pilots and go into the air because they believe that this is the only true way to understand and care for those who fly. But basically their work lies in their probing into the mysteries of the human body's reactions to the varying conditions that arise in flight, in testing the reactions of brain, organs, limbs, tissues and blood. This research leads to the development of a protective system, or piece of equipment or clothing.

It is a saying in scientific circles that to copy from one book is plagiarism, but to copy from three is research. I am glad of that for, in preparing the chapters on legend and history I copied from five, which must surely place my scientific integrity beyond dispute. Should the reader have no time for history and be avid for the 'meat,' he would do well to skip those pages. There is however much of interest and indeed excitement in the story of the early mountaineers and balloonists. After all one of the first men to fly was a doctor and he was certainly the first to fly the Channel. An American physician from Boston, he has given his name to the annually awarded John Jeffries Award for the greatest contribution to aviation medicine. We in the medical branch of the Royal Air Force are particularly proud that the American Institute of Aeronautical Sciences honoured our Director General Air Marshal Sir Harold Whittingham with this award in 1944.

In view of the increasing interest taken in all the sciences, I have endeavoured to outline some of the more important aspects of this branch of Medical Science, but only as background to the work and adventures of the doctors concerned. For this book is mainly about people and not things; splendid people whom it has been a great privilege to know, and indeed to learn from, in trying to write their story.

1

To Fly Like That

I

'TO fly like that. To do it all unconsciously merely by bringing this or that set of ten thousand flight muscles into play, as we will to rise, to float, to fall—to go this way or that—to let the wind do it all for us, as it were, while the sight is occupied and the mind is wholly free!' This cry of the great naturalist W. H. Hudson, echoes so well man's constant desire for the divine freedom of flight. From time immemorial, in myth, legend and history, men have looked up and yearned to emulate the birds. The human conception of angels or devils since the earliest times has endowed these supernatural beings with wings and the power of flight.

Many are the stories of aerial endeavour in the legends of Persia, China and India. One Hindu poem even describes a whole city that flew about at will attacking its discomforted enemies from the air. Persian history tells of king Kai Kross, who lived 1,500 years before Christ, and is reputed to have realised his ambition to fly by harnessing eagles to a light throne above which were suspended pieces of flesh just out of reach of their powerful beaks. Striving for the food the eagles bore the throne aloft, but possessing more intelligence than Kai Kross expected the birds tired of such useless pursuit and dropped the luckless monarch into China.

The most famous flying legend of all time is that of Daedalus and his son Icarus. These ancient Greeks, imprisoned on the Island of Crete, made their escape by fashioning wings of birds feathers and attaching these to their shoulders with wax. All would have gone well if young

Icarus, in the excitement of his 'first solo' had not flown too near the sun, which melted the wax, causing him to plunge to his death. His more staid father is said to have landed safely in Sicily.

In 852 B.C. Bladud, the mythical tenth king of Britain, made an attempt to fly which ended in his death. The legend runs that Bladud, supposed founder of Bath and father of King Lear, was a practised magician who taught these arts throughout his kingdom. But, as many a showman since has found to his cost, it is necessary to perform ever more dangerous and miraculous tricks to maintain a reputation. Fabyan's Chronicle of 1516, relating the story for the first time in English, reports that, in the pride and presumption of his magical skills, he finally took it upon himself to fly into the air from which he fell on to the Temple of Appolyn in London and not surprisingly he was 'all torn.' His chroniclers seemed to have had little sympathy with this endeavour, and for the most part mocked at the King's vanity and pride.

Leaving the years of legend, two flights in the 17th century are interesting to recall. Whereas the early stories appear to have been mere wishful thinking, Oliver of Malmesbury and Damian the Abbot of Tungland must have used some sort of contrivance of a practical nature in their efforts to fly. Milton, in his history of Britain, 1670, describes rather contemptuously how the 'conceited' monk Oliver, attaching wings to his hands and feet, fluttered from a tower for more than a furlong before he fell breaking all his limbs. Oliver himself appears not to have been too despondent as he blamed the failure on his omitting to provide himself with a tail like the birds.

John Damian, an Italian by birth, became a favourite of King James IV and resided in the Scottish Court at Stirling as physician to the royal family. Though his record is that of adventurer, quack doctor, and opportunist, his attempt at flight, in which he risked both his life and reputation, does indicate the use of some sort of wing though we do not know what it was like. In the autumn of 1607 an embassy was sent to France and Damian boasted he could overtake it by flying there. John Lesly, Bishop of Ross, tells of the aeronautical venture in his history of Scotland. This Abbot, he writes, undertook to fly with wings and be in France before the Ambassadors. Making one pair of wings with feathers and with the quills bound fast to him he flew off the wall of Stirling Castle but shortly fell to the ground with a 'breaking of bones.' Damian, with self-assurance equal to that of Oliver of Malmesbury before him, ascribed his failure to the inclusion of hen's feathers in his wings; claiming that their attraction to the dunghill was greater than their ability to maintain flight.

The isolated incidents of attempted flight, reported in various histories from the 12th century onwards, all led to failure. It is obvious that scientists and clerics spent much thought and speculation on the possibility of conquering the air. There were many ingenious devices postulated and designed to raise man above the earth on wings or machines. Some learned men wrote thoughtfully, and indeed prophetically, on the subject and some of their theories and suggestions came near to the truth. Roger Bacon in the 13th century gave us the first rational ideas of flight and sincerely believed in the possibility of its achievement. Giovanni Danti, a mathematician of Perugia, is said to have attempted winged flights over a lake and to have shown evidence of practical ideas. But it was that great genius Leonardo da Vinci, who, two hundred years after Roger Bacon, delved into the problems of flight and applied his masterly brain to the design of winged machines and even helicopters. He built models that actually flew and he left a scientific deposition on the principles of the parachute. However, his manuscripts remained in obscurity for another three hundred years and the conquest of the air remained as remote as ever.

But, most of the writings on aeronautical matters lingered in the realm of pure romance. Their authors, like those of space fiction today who write of journeys to the moon and sun and the adventures of winged humans, had very little idea of how such feats could be achieved. The literature of England and the continent, particularly Italy and France, were full of imagery and the glory of flight. Cyrano de Bergerac, famed in love and war, related journeys to the solar and lunar worlds in his 'Comic History of the Moon and Sun,' and lightheartedly raised his characters into space with the aid of dew contained in glass balls raised by heat from the sun's rays. Another method he advocated was the use of a very light machine of iron raised by the power of the loadstone, though what would be used to raise the loadstone is not recorded!

It is not until the ascent of the first balloon in the 18th Century that the story of exploration into the atmosphere and its devious effects on man can begin. But, before recalling the thrills and dangers of those first aeronauts, it is of interest in the story of aviation medicine to examine some of the adventures of the early travellers through mountainous regions, for it is here that the trials and sufferings of men at great altitudes are first consistently recorded. The attitude of the ancients to high places of the world was one of fear and dislike and for the most part they never attempted to climb the mountains unless forced to in the course of a journey. Then they kept rigidly to the passes such as the Simplon and the Great Saint Bernard where the height is insufficient to produce mountain sickness. So strong was this fear of mountains that even great peaks like Mont Blanc or the Jungfrau have no names in the classical languages. The only exception to the general rule is Mt. Etna which was climbed many times voluntarily. The Emperor Hadrian, an enthusiastic traveller, climbed to the top to see the sun rise. But in these accounts there is no mention of physiological symptoms, though at the height of this volcano they might only be mild and would probably be attributed to cold or fatigue. Thus it was not until after America was discovered and the Spaniards began their journeys of conquest into Mexico and Peru and across the mighty Cordilleras that heights were reached sufficient to cause mountain sickness which was noted by their historians.

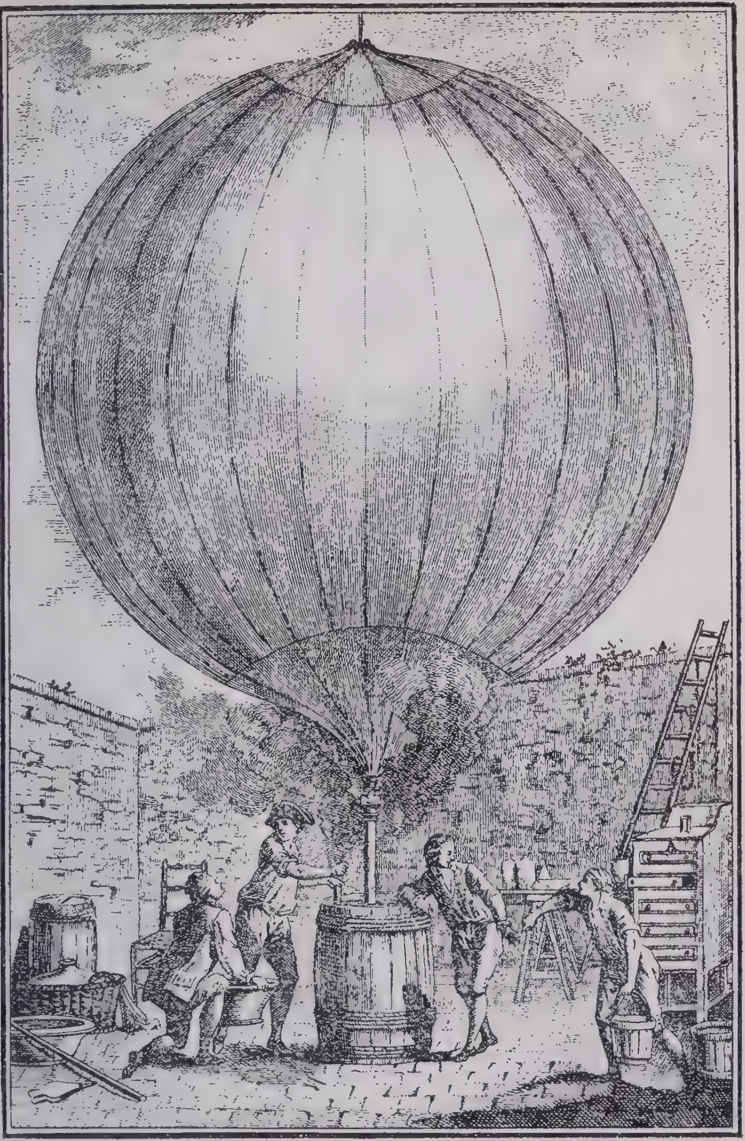
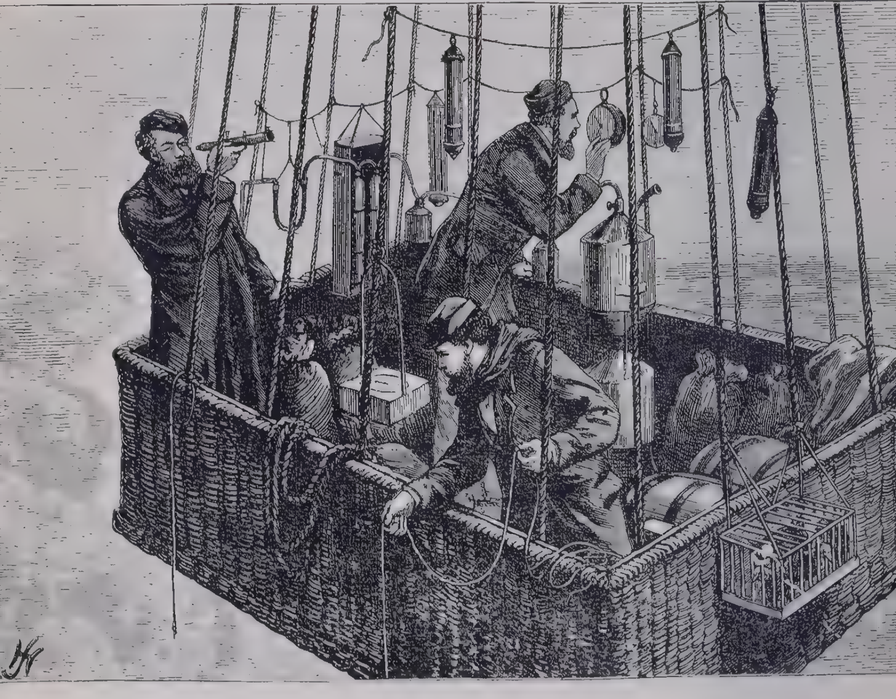


PLATE 2

The physicist Charles and the Robert brothers filling the first hydrogen balloon.

PLATE 3
Glaisher and Coxwell in the car of their balloon about 1862.

A contemporary drawing of Tissandier and companions before the fatal accident. Note the scientific apparatus and oxygen containers.



It was in 1519 that the great Spanish soldier Cortez attacked Mexico and in that year and three years later an expedition ascended the towering Popocatepetl at his order. The crater of the volcano is at 17,800 feet, well above the height for sickness to occur but in the record of the second ascent there is nothing very definite to indicate that these intrepid explorers suffered the expected symptoms. Twenty five years later Francis Pizzaro led an expedition of horsemen and foot soldiers from the Pacific Coast over the terrible passes of the Cordilleras of the Andes to reach Cuzco deep into the empire of the Incas. The historian of this daring journey, while writing of the many dangers encountered, only briefly mentions the bitter cold they suffered at the extreme heights although they were below the snow line. In the years to follow there are accounts of huge losses suffered by the Spaniards and their parties adventuring among the heights of the South American mountains. In one expedition fifteen Spaniards, several negroes, two thousand Indians and six women are reported to have died. The survivors escaped with deathlike faces, from the snows suffering frostbite, many losing their toes and even their feet. The narrative records that some had gone blind. A year later a similar march undertaken in the winter, when the days are short and the cold at its worst, resulted in the death of 10,000 of the 15,000 who set out. Over a hundred of these were Spaniards. Negroes, Indians and their horses frozen and numb made little progress through the snows and their plight was worsened as the food began to run out.

These extracts from the accounts left by the historians serve to show that in those far off days there was no understanding that the rarefaction of the air at great heights and the consequent lack of oxygen to the lungs was the cause of the unknown disease and its frightening symptoms. The various accounts of the sufferings of these early pioneers blame only cold, fatigue, and shortage of food. But at the end of the sixteenth century a Jesuit priest, Father Acosta, left a vivid description of the sickness he experienced while travelling in the South American mountains. He is perhaps the first to relate the symptoms to the air of high places and to note that the symptoms occurred only at extreme heights. It is fascinating to read the highlights of the records he left. He writes that, with some companions, he was exploring a lofty peak in Peru called Pariacaca and, though briefed by experts, was ignorant of the true effects of the high passes through these mountains. He goes on that while ascending he was attacked by a strange and deadly disease and almost fell from his horse. His companions, each one intent on his own survival, increased their pace in a hurry to escape from the evil spot and so left him alone with one Indian. While he was receiving help from the native he was seized with spasms of panting and vomited food and green and yellow bile. His alarm and fear of dying was increased when he began to bring up blood and fierce pains ravaged his stomach. This suffering lasted three or four hours until he had rejoined the others at a lower level. Many of them were still in the throes of the sickness, racked with vomiting and diarrhoea, and completely exhausted; some of them begged him for confession, thinking that death could not be far off. He goes on with his story by drawing attention to the occurrence of the puna, mareo or sorache as it is variably called, at other places in the mountains but always at great heights, and further noted that not only men but animals suffered, sometimes with such distress that no goad or spur could make them move.

From this time onwards there are many accounts by travellers in the mountains of the various effects on men and beasts of the thin air of what was often called the middle regions of the atmosphere. But with few exceptions no very clear understanding of the real cause of the punas was shown in the writings of the explorers and their historians. Father Acosta wrote of his adventures and journeys towards the end of the sixteenth century, three hundred years before the true composition of the air and its vital oxygen content was discovered by the physicists. He must have been remarkably learned and clear thinking to have come so near to the truth. But still another fifty years were to pass before the barometer and the vacuum pump were invented. Before that no laboratory experiments were possible on the effects of rarefied air. Too numerous to relate here are the records of ascents and the suffering of those intrepid early explorers. With the growth of science during the following centuries more and more mountains were climbed, not just in the course of a journey or campaign but to investigate the properties of the air at these levels.

One very clear and frightening account is left by the eminent German traveller Tschudi who relives in his story the twenty four hours he spent on the icy Puna of Peru at a height of 14,000 feet. The first effect he noticed was a peculiar distress and great difficulty in breathing; to do so at all he had to be still and quiet. Any exertion seized him with terrifying anguish and with his heart beating against his ribs his whole chest felt flattened by a great weight. Lying trembling on the ground, lips blue and cracked, his senses were dimmed and altered. His sight was blurred by a red grey cloud and, tiny vessels in his eyes having burst, he shed bloody tears. Hearing and touch were strange and unreal, and like Father Acosta, centuries before, he felt that death could not be long delayed. He goes on that, while lying there, if uncountable wealth or immortal glory had been but a few steps further on he would have been unable to even stretch out a hand towards them. However, he recovered a little and managed once more to climb on to the mule and proceed on his way.

Some mention must be made of a few of those who delved and discovered so that modern doctors and physiologists have been able to prevent most of the dread symptoms which have afflicted those who venture into the high places on foot, in balloons or on wings. Most important is Robert Boyle, a physicist, who returned from study on the continent to England in 1644 and eventually settled himself in Oxford. He had for his assistant Robert Hooke who was mainly responsible for developing Boyle's first air pump. With this equipment he experimented, with animals and birds, on the effects of rarefied air and vacuums. Also, using a flame in a jar upturned in water, he discovered that as the flame burned the water rose in the jar, showing that the flame used some part of the air. His 'suspicions about some hidden qualities of the air' and its vital 'springiness' were both published as papers. His main conclusion was that this unknown quality was essential to support life as well as flame, and that the remaining part of the air still retained its own pressure. Writing of mountain sickness, Boyle records the effect of diluted air on animals in a chamber evacuated by his pump. He imagined that a man exposed to the uppermost atmosphere would only live a very few minutes, a prophecy proved only too true by experiences of balloon and aircraft flights through the years to come. He continued his paper by referring to that same learned Father Acosta whose suffering and brilliant record was re-told earlier in this chaper. Robert Boyle too, enthused over the accuracy and clear-sightedness of the Father's reports.

The work and research of other scientists, that of Stephen Hale in particular, led finally to the isolation of oxygen by Joseph Priestly in 1774. While working in his laboratory he concentrated the rays of the sun through a magnifying glass on to red oxide of mercury to produce a gas in which a flame would burn five times more brightly than in air. Priestly had no true name for the newly discovered element which was christened nine years later by Lavoisier, the brilliant French scientist of his day, as 'oxygine' and later as 'oxygen.' All these important discoveries of the properties of various gases led in their turn to the ascent of the first hydrogen balloon, shortly after the Montgolfier Brothers, to the amazement of Europe, had successfully flown their balloon which was raised only by hot air. The era of true flight was opened and, although more than a century was to pass before the Wright Brothers achieved powered flight of a heavier-than-air machine at Kitty Hawk in 1903, much that concerns our story of medicine in the air and its characters is to be found in the adventures and tragedies of the balloonists.

II

THE Montgolfier Brothers, sons of a French paper manufacturer, noticed that a paper bag would rise into the air when filled with smoke from a fire beneath it. Experimenting further they constructed a balloon, one hundred feet in circumference, which they inflated with hot air from a fire of chopped straw. This first balloon ascent was made in 1783. The amazement and wonder caused by this flight culminated in another ascent some few months later made before Louis XVI and a great multitude at Versailles. This time passengers were carried, though cautiously, for they were a sheep, a cock and a duck. They ascended to 1,500 feet and landed safely. It was then arranged with some haste for a flight to be made by a condemned prisoner who would be granted his freedom if all went well. Rather sadly one feels, for some unfortunate awaiting death, a chemist Pilatre de Rozier came forward protesting that the glory of being the first to fly should not go to a criminal. De Rozier won his point and made his flight in a captive balloon during which he discovered that he could control the rise and fall by feeding or damping the fire. He was accompanied by a French marquis as a passenger a month later on his second successful ascent. Two years later de Rozier, true to his earlier enthusiasm, invented his own balloon in an endeavour to emulate the first crossing of the English Channel by balloon. His method was to use hydrogen to give the balloon lift and a fire to regulate its position. His ardour must have far outweighed his common sense, not to mention his scientific knowledge, for even when warned by the physicist Charles he persisted in making hydrogen and fire near neighbours. The expected calamity happened and before the horrified eyes of the crowd which tragically included his fiancée, de Rozier crashed to his death when the balloon disintegrated in a mighty explosion. His companion lived only for ten minutes longer than his foolhardy pilot.

But it was the true hydrogen balloon, rather than the hot air balloon, which was of real interest to physicians until it was superceded by the aeroplane. Jacques Charles, a physicist directing the work of the two brothers Robert, devised the first hydrogen balloon in which he ascended two months after the ascent of the unfortunate de Rozier. Charles suffered no more than a pain in his ear which he quite rightly blamed on to the expansion of the air inside the organ. The height reached was about 3,000 feet where the balloon stayed for three quarters of an hour. A year later a flight of great interest took place. An American doctor John Jeffries, having served in the British Forces during the American Revolution, decided that as a loyalist it might be wiser to practise in England for a while. He became intrigued by the problems of aviation and as well as being the first doctor to fly, he was amongst the earliest to take a scientific interest in the properties of the atmosphere. He left a narrative of his two flights, both of which he made with Blanchard, the famous aeronaut and engineer. The first ascent was made from London. It was to investigate the possibility of controlling the rise and fall; the use of oars or wings to steer the machine on a true course; to observe the quality and temperature of the air at different levels; and by noting the currents of air, to throw fresh light on the theory of winds. Taking with them a variety of scientific equipment they rose to 9,000 feet and were in the air for an hour and twenty minutes. Jeffries gives us the impression of a gay fellow despite his scientific enthusiasms for he writes that at that altitude they did justice to cold chicken and drank a few glasses of wine to the health of their friends below.

It is doubtful if the news of the crossings of the Atlantic by Alcock and Browns, or Colonel Lindbergh, caused more stir through the world than the passages across the English Channel achieved by Jeffries and Blanchard in the year 1785. They started out from Dover and finding their ascent alarmingly rapid they released some of the gas, but not being able to judge the correct amount came near to disaster when halfway across. They started to fall and when disposal of all their ballast proved of no avail, over the side went wings, oar, rudders, coats and their scientific apparatus. The balloon rose again but later descended when only a mile from the French coast. Desperate measures were taken and they feverishly discarded some of their clothes, their lifejackets, and some of the food. An upcurrent of air mercifully lifted them clear of the cliffs and they found themselves over the trees of the forest of Guines. But this was only a respite, for Jeffries feared that the car might be torn from the balloon which was now descending again with great speed. By now practically everything had been jettisoned and the prospect looked grim. However, professional knowledge came to their aid for he suddenly remembered that they had breakfasted well with plenty to drink and as neither of them had obeyed a call of nature since then, now was the time to perform a natural function and so achieve a further loss of weight. Jeffries writes that he earnestly believed that the five or six pounds of water that went over the side was of real use in their plight. Whether or not this was the cause, their descent was checked and by judicious manœuvre with the help of the branches of the highest trees and the release of more gas at the right time he brought them safely to rest in a clearing.

The two gallant men emerged from the car of the balloon cold and nearly naked to be met by enthusiastic peasants who soon clothed them. Local officials of Calais offered a tremendous welcome which was continued in Paris for no less than two months. Dr. Jeffries, completely exhausted by the fêtes and hospitality, at last escaped to England where he resumed the more staid routine of practice. Later he returned to Boston, U.S.A., and once again took up medicine in his home town where his loyalties appeared to be no longer in doubt. He is honoured today for his courage and scientific endeavours by an award given each year by the Institute of Aeronautical Sciences to the doctor who makes the greatest contribution to the cause of aviation medicine.

Many hundreds of balloon ascents were to be made in the years to come in nearly all the European countries. Some of them were carried out in scientific and military interest but by far the greater number were exhibitions for prestige and money. The first Englishman to fly was the now famous Dr. Jenner, the discoverer of vaccination as a protection against smallpox. In the first decade of the nineteenth century two scientific flights were made, one from Italy, and the other a year later from France. The Italian balloon carried a crew of three, one of these being a doctor. They all suffered from the lack of oxygen, two of them vomiting and becoming unconscious, the third noting that he was unable to read the barometer as the candle in the lantern became dimmer and dimmer as the height increased and the air more rarefied. The tremendous flight nearly ended in disaster when they descended into the Adriatic. Luckily they were rescued but all suffered severe frostbite and the leader had to have three fingers amputated. The French venture was made by a young man, Joseph Gay-Lussac, who was sponsored by the Academy of Sciences. He returned with much useful information as to temperatures and pressures of the air, and at the same time achieved the altitude record of 22,000 feet. Many other claims were made at this time to flights of greater height but they were never substantiated. So the ballooning went on for the next fifty years all over the continent but added very little of scientific value either to medicine or aeronautics.

The next flight that must interest us is one of twenty eight made by two Englishmen, Coxwell and Glaisher, the latter a skilled meteorologist, the value of whose observations on the quality of the atmosphere at altitude and its effect on man were enhanced by his scientific background gained at the Greenwich Observatory. On the fifth of September in 1862 these two scientists made their epic flight of which James Glaisher leaves so exciting a record. When they reached a height of 17,000 feet their troubles began and Coxwell, who was doing most of the piloting, became breathless and weary. The cold was intense and Glaisher had difficulty in reading the figures of his scientific instruments. Coxwell was unable to help with the readings for the cord of the valve had become entangled by the constant revolving of the balloon and to free it he had climbed out of the basket on to the ring. Glaisher goes on to describe his symptoms as they climbed ever higher. He records how he became weaker, his head drooped and he was eventually unable to move at all. His vision went black and though still conscious he was seized by a thick darkness. He thought he was suffocating and bitterly concluded that his experiments were at an end and death would be swift if they were not able to descend. He finally succumbed to the darkness and fainted. Later he recovered consciousness to find Coxwell trying to rouse him to report his success with the valve. The efforts of the pilot had indeed been heroic. While out on the ring, where the cold was so intense that great polar icicles hung from the orifice of the balloon, he had lost the use of his hands. Being unable to grasp the cord he seized it in his teeth and was at last able to release some of the gas and start the descent. He could only return to the basket by sliding down on his elbows where he found the unconscious Glaisher, who on recovering from his faint poured brandy over Coxwell's blackened and benumbed hands. At last on the ground they both appeared to have recovered completely for they were able to walk eight miles from the place where they had landed.

About this time the French physiologist, Paul Bert, was interesting himself in the problem of atmospheric pressure and its effect on man and animals. His experiments and work on this subject in laboratory and decompression chamber resulted in a classic book on barometric pressure. To his laboratory in Paris in 1874 came two balloonists named Sivel and Croce-Spinelli. They wished to subject themselves to low pressures in his chamber and to learn from Bert the secrets of the use of oxygen to support life at great heights. They then made a successful flight to very high altitude taking with them bags of oxygen to breathe. On their next ascent a month later they were joined by one Tissandier. They planned to climb to a great height and to save their oxygen to use at the last moment. Paul Bert had written to warn of the dangers of such a procedure, but his letter must have arrived too late to deter them. The most interesting part of Tissandier's graphic description of the flight is his experience of the first stages of oxygen deprivation which are so closely akin to drunkenness, in the elation and joy that is felt and the utter indifference to the dangers involved. They climbed to 29,000 feet and all three became unconscious, from this height miraculously the balloon descended of its own accord but of the three only Tissandier survived to tell of the paralysis which prevented them from reaching their oxygen and so led to the death of Sivel and Croce-Spinelli.

The twentieth century would bring with it powered flight and by the end of the second world war the aeroplane would carry man, if not beyond his wildest dreams, certainly higher and faster than had been thought possible by scientists in the past.

Medicine now assumes a more important part in the story of the air.

III

THOUGH it was the French who took the lead in ballooning the initiative passed to England for the early experiments with heavier than air machines. In 1840 Pocock, a schoolmaster of Bristol, made and exhibited a kite that would lift a man. He had, some years earlier, recommended the use of kites for pulling carriages and for military use, in place of balloons. A more reasonable and scientific line was taken by Henson and Stringfellow, a few years after the optimistic teacher's efforts, when they built a model aircraft similar to a modern monoplane. It was powered by steam and was the first power driven machine to stay in the air. But much had to be learnt of the principles of aeronautics before airframes could be made capable of sustained flight. Stringfellow, in his records of his flying model, complained of the weakness of the frame and considered the steam engine itself to have been the best part of the project. Progress was being made, however, and the nineteenth century contribution to the conquest of the air was on the right lines. As a learned man of that time said of the pioneers, 'they got hold of the right questions and strove to demolish the old fallacies.'

One doctor who must be mentioned is William Crofton Moat, M.R.C.S., who, with what appears to be a remarkably slight understanding of the engineering problems of flight, entered the field of theoretical aeronautics. He spent a vast amount of time, energy and money on writing papers, taking out patents and holding meetings to support his project for steam flying conveyances. His optimistic anticipation of the jet age suggested the construction of a machine of about 20 tons which would fly to anywhere in the world in less than a day and with perfect safety, and ease of management! But he never made any models or carried out any tests of a practical nature. The doctor, with a touching faith in the human race, also prophesied that such machines would stop wars for all time and reunite friends from the ends of the earth.

Serious work, however, was going on in America, France and Germany as well as in England into the properties of wing shapes and their ability to give lift. Gliders and steam driven aircraft, both model and man carrying, were tried in the closing years of the century. The death of Lilienthal in Germany in a gliding accident stimulated the Wright Brothers to begin their research into aviation in 1900. The efforts of the gliding pioneers and their achievements of stability and control of their machines only needed the addition of the internal combustion engine to fulfil the centuries' delayed ambition of controlled flight. The honour was to go to Orville and Wilbur Wright who, after three years' work, designed and built the aeroplane in which Orville Wright flew 120 feet in 12 seconds on December 17th, 1903, at Kitty Hawk in North Carolina.

The next ten years saw big advances take place in design of airframes and engines. In France the first to fly was a Brazilian named Santos-Dumont who succeeded in a machine built and designed by himself. Three years later in 1909 Bleriot flew the English Channel causing wonder but also an uneasiness; for 'the ditch' had been the safeguard of England's sovereignty. In the same year Moore Brabazon, now Lord Brabazon, was the first Englishman to fly and to achieve the Royal Aero Club Aviators certificate No. 1. (Nearly forty years later he gave his name to the mighty Bristol aircraft constructed after the last war.) Engines became more powerful, and speeds and heights obtained increased every year. By 1914 power plants of 200 horse power were in use and had raised the altitude record to over 20,000 feet and the speed to 125 miles an hour. Long journeys of over 500 miles had been made and mail and passengers had been carried. Alongside this peaceful development, and in sombre defiance to Dr. Moat's hopeful prophecy of sixty years before, grew the increased interest of the nations in aircraft and their possible uses in war. First America, in 1908, signed a contract for the supply of war planes, and over the next few years most of the European countries followed suit, and the scramble for air supremacy had begun.

Our own fighting services became air-minded in 1912 with the formation of the Royal Flying Corps and its naval wing, later to become the Royal Naval Air Service. At the same time a doctor was appointed to each of the two air arms; Captain E. R. G. Lithgow, R.A.M.C., to the R.F.C.; and Staff Surgeon H. V. Wells, R.N., to the naval wings. They soon appreciated that the problems of aviation could not be studied best by sitting on the ground. Their keenness to experience and examine for themselves the hazards and, indeed, the rewards, of flying resulted in the award of their Royal Aero Club Certificates in the year 1913. Lithgow won his wings on a Short plane at Upavon in Wiltshire, for many years the Central Flying School of the Royal Air Force, and Wells qualified three months later on a Bristol aircraft at Eastchurch. During these years a number of papers were published by physiologists on the problems of the body and its environment in flying, but though full of interest both historical and scientific, to recall them would leave no space for the main object of following the doctors into the air. Next on the list must be H. Graeme Anderson, M.B., Ch.B., F.R.C.S., a surgeon who joined the Royal Navy at the beginning of the war and was attached to the Royal Naval Air Service. For four years he lived and flew with aviators, and like Wells and Lithgow before him, learnt to fly while he was medical officer of a large flying school.

In his book, *The Medical and Surgical Aspects of Aviation,* which he published when out of the Royal Navy and back in Harley Street, he has a delightful account of his own first solo. One day, he writes, he had been flying dual with his instructor when, much to his surprise, the instructor climbed out of the aircraft when it came to a standstill after landing. Anderson recalls that he was further surprised when instead of inspecting a tyre and climbing in again the pilot told him he was now all right and to 'push off' alone! There being no chance to debate or delay he forced himself to 'draw down the mental curtain on his imagination,' seized the stick and throttle and 'pushed off' with a bit of a swing to the left. He quite successfully flew two circuits and came in to land, though his account modestly claims that his arrival was not quite 'according to the book.' In the two years that Graeme Anderson spent at the flying school he must have been asked his advice many times on the problems that faced the youngsters learning to fly. The point he emphasises strongly, following the story of his own experience of going solo, is that the pupil should have very little warning of the impending event and so have no time to become anxious as to his ability to succeed. It is doubtful whether such sound advice would have been taken so readily by his flying instructor friends, if Anderson's keen interest in all the aspects of flying training had not taken him into the air to find out for himself.

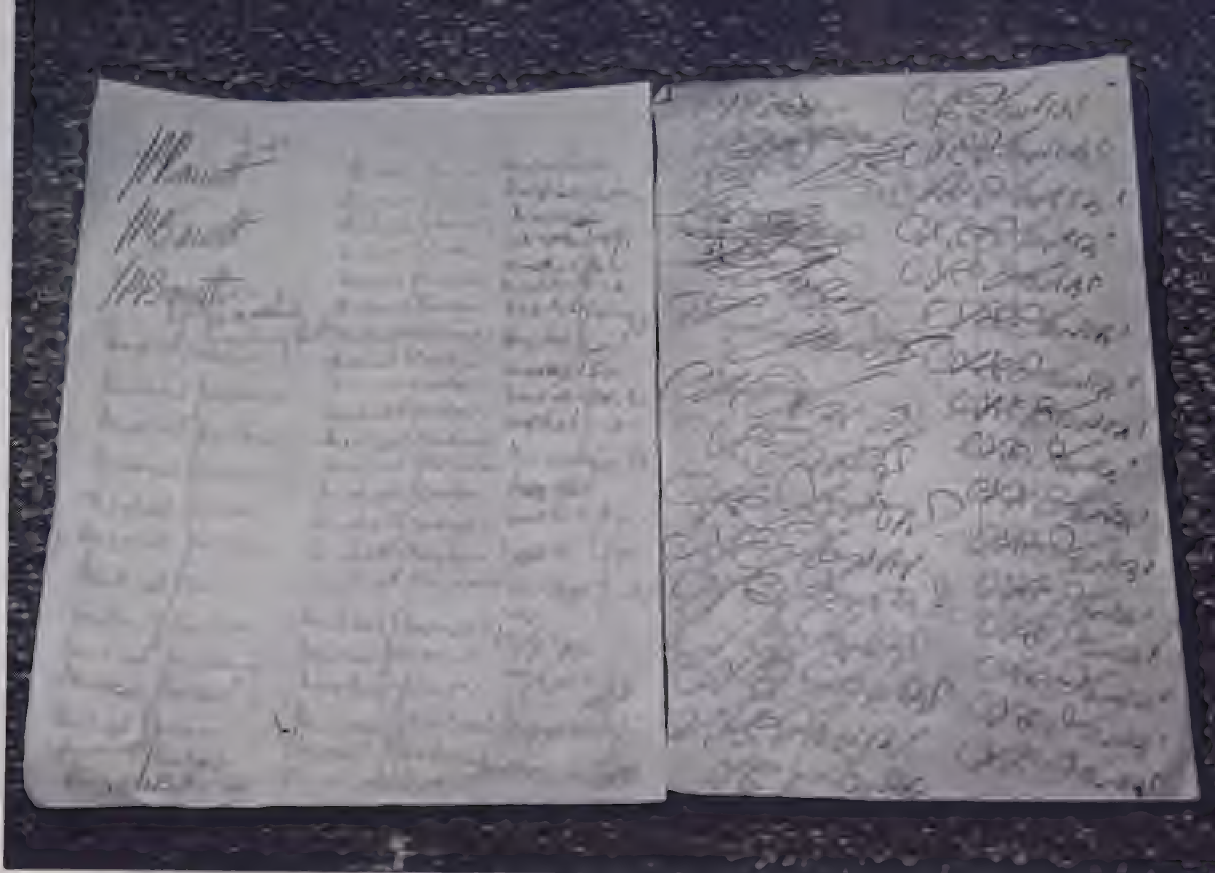
Meanwhile the war in the air was becoming even more intense. At the beginning aircraft were used only for reconnaisance and flew unarmed. But this phase was short lived and man's proclivity for throwing things at one another led, through an early stage of bricks, other missiles and rifles, to the machine gun, and the bomb. Increasing numbers of warplanes, fighters, and bombers began to come off the production lines of the warring countries, each different type bringing with it new problems for the flying doctors. Oxygen equipment had to be developed, as the planes flew to heights where the lack of oxygen must affect the crews' efficiency. There were no windscreens in those days and the pilots and crews were exposed to the full effects of the slipstream. Goggles to protect the eyes; and helmets, 'flying clothing to keep out the piercing cold,' were other needs that occupied the attention of these first doctors to devote themselves to the need of aviators. The violent manœuvres of dog-fights between the opposing fighters called for the design of effective safety belts to keep the pilots fast in their seats even when upside down. Remarkable advances were made in the development of protective clothing for the crews of that time. Lieutenant-Colonel Martin Flack, writing in Graeme Anderson's book, reports the use by aviators of flying suits and other gear which were quite as advanced as the equipment used in the first stages of the last war. Oxygen masks, with microphone attachment, electrically heated suits and gloves and anti-glare goggles are all mentioned as having been tested and used. Lieutenant-Colonel Flack was also responsible for the origin of the all important tests used in the medical selection of aircrew. Many of these, particularly 'blowing up the mercury' will be only too familiar to the hundreds of thousands of men who have passed through the Medical Boards of the R.A.F. and, in peacetime have to satisfy their medical officer once a year that they are still fit to fly. Though many medical students flew on operations against the enemy as pilots and crew, and, if they lived, later qualified as doctors, only one physician in the Empire gained his wings and flew against the enemy. He was Captain Halliwell, C.A.M.C. who qualified as an active service pilot in 1916.

An American Medical Mission arrived in Europe in 1917 to study Aviation Medicine in England and other allied countries. They found that, although the general medical and surgical services were the best possible, there was an urgent need for doctors in the field trained in the care of aviators. The mission reported that the aircrews' health was not good, their morale low and the flying accidents were killing three times as many as those lost in enemy action. General Lyster, known in America as the father of aviation medicine, in response to an urgent cable from the Supreme Commander, sent post haste 34 American doctors to France. They were all from the Air Service Medical Research Laboratory and skilled in the methods of selection and the physiology and psychology of aviators. These doctors were the forerunners of Flight Surgeons for which a school was later set up in 1919 in the United States. Some of these first specialists were assigned to flying duties and gave a splendid account of themselves. Major William Ream was the first flight surgeon to lose his life, when he was killed in a flying accident in the summer of 1918. In a short time after the arrival of these doctors, trained in aviation medicine, their care and knowledge of aircrew markedly reduced the loss of life from flying accidents. Commanding Officers of the squadrons and flying formations ungrudgingly gave credit for this improvement to the flight surgeons.

In England in 1917 the R.F.C. Special Medical Board, and Martin Flack from the Medical Research Committee, continued their work on all the aspects of the health and selection of the pilots of the R.F.C. and the R.N.A.S. A Central Air Hospital was formed devoted to the illnesses of naval and military flying officers, and in 1918, with the fusion of the two air arms into the Royal Air Force, a separate medical service came into being. A special medical flying school was formed in the same year where standards of fitness could be tested and doubtful cases of pupils who had failed to make the grade at flying school, could be investigated and recommendations made on the findings. This brief glimpse at the work of air doctors from 1914 to 1919, shows how well established had become the need for special training and research in aviation medicine. It was and is today essential that experiment into the limits of bodily endurance, and its protection above those limits, must go on ceaselessly. The results of the findings in decompression chambers, hot and cold tunnels and laboratories, must all be tried in the air by doctors as well qualified to fly as the crews they serve. Wells, Lithgow, Graeme Anderson, and all others of that first World War have left a tradition of service whose message is quite clear. Only by experiencing all the discomforts and dangers of the fighting aircrew is it possible to produce the right answers to the problems of flying at heights and speeds, into regions of the atmosphere, and against opposition, that are outside man's bodily and sometimes emotional limits.

PLATE 4

Writing tests made in the decompression chamber. On the left writing deteriorates as anoxia increases. On the right the improvement when oxygen is added.



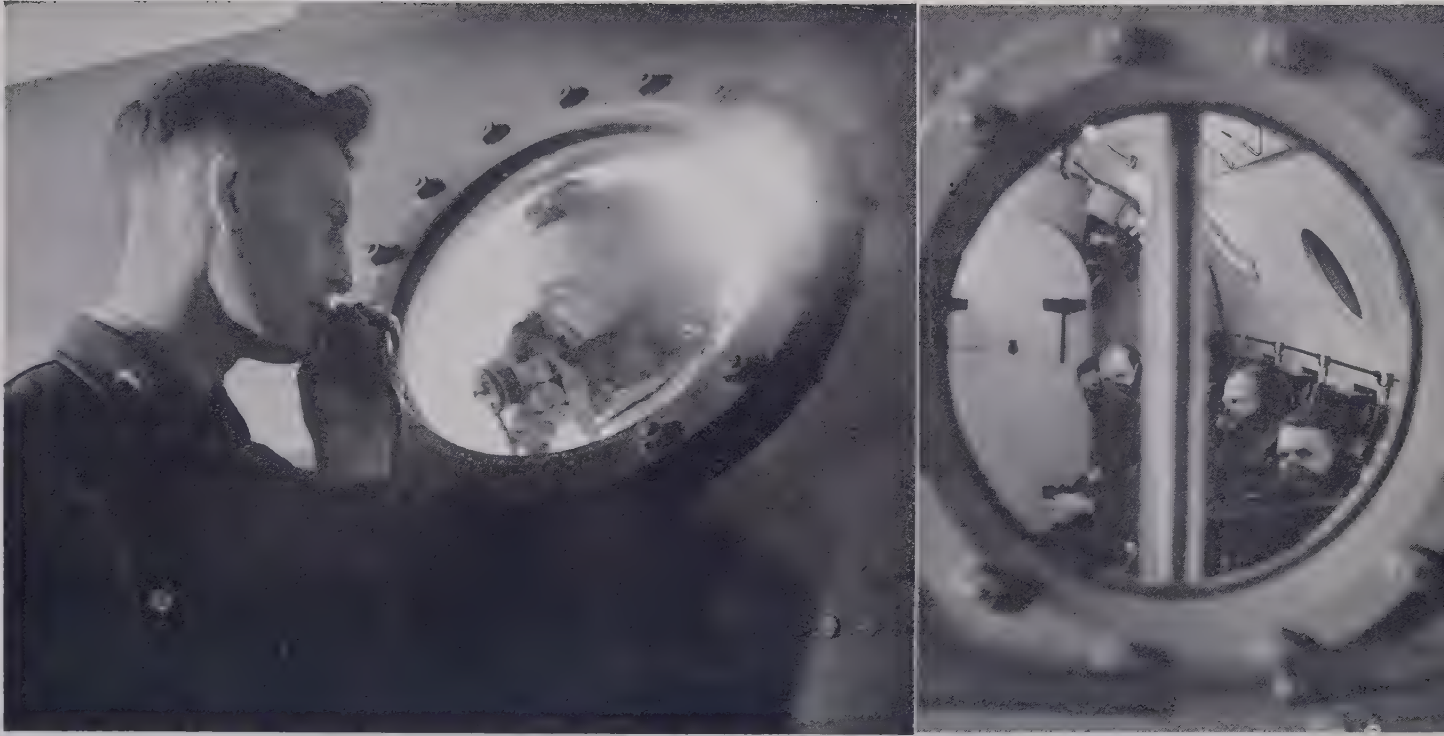


PLATE 5
Two photographs of subjects going up to high level in the decompression chamber. Note the means of communication between the operator and those inside the chamber.

2

Into Thin Air

THE years following the first world war and the gradual return to peacetime routine led to a comparative lull in research and concern with aviation medicine. But with the rise to power of Hitler in 1933 and through the uneasy years to follow, the world powers all renewed their interest in the physiology of flight and the powerful effect it could have on war in the air. Munich and its short-lived 'peace in our time' came and went. The Royal Air Force expanded enormously as tension in Europe mounted. Hurricanes, Spitfires and Wellingtons were no longer drawing board schemes and their prototypes were flying. Early in 1939 the Secretary of State for Air formed the Flying Personnel Research Committee on the advice of Air Marshal Sir Victor Richardson, the Director General of Medical Services. Under their chairman, Sir Edward Mellanby, the committee laid out a programme of basic research into the medical problems of service flying. Physiologists at the Universities were warned that their services would be required urgently in the event of war breaking out.

Eight months later we were at war with Germany. The R.A.F. Physiological Laboratory, which until then had been housed in a hut at Hendon Airfield, moved to Farnborough. Group Captain Struan Marshall was joined by Dr. B. H. C. Matthews from Cambridge who was to head the team of doctors at Farnborough through the rest of the war years. It has been said many times that in the political sphere a man comes forward to lead in the nation's hour of need. It is certainly an undeniable fact when applied to our Prime Minister of the Second World War. Rather in the same way the selection of Dr. Matthews as head of the Physiological Laboratory was an example of choosing the right man for the job. Already in 1936 one of the outstanding physiologists in the country, he had taken part in the high altitude expedition to the Andes in that year. One of his staff has told me that his mastery of physics and, without exaggeration, his genius mechanically, were exactly the qualities required to devise and develop urgently needed oxygen systems and other equipment for protection of aircrew against the various hazards of flight, about which comparatively little was known. The first urgent problem for the staff in these early days was to devise an efficient and economical oxygen system.

I have emphasised, in the history of the early mountaineers and balloonists, the severity of the symptoms of insufficient oxygen at the comparatively modest heights to which they ascended. In the introductory incident of Stainforth's flight, the height he reached in no way compared with the altitude which could be envisaged in the aerial warfare which was to come. During the first 'phoney' months of the war the R.A.F. were concentrating on building up high flying photographic reconnaisance units that were later to produce vital information for the Bomber force. The aircraft used were Mark I Spitfires specially stripped of all unnecessary equipment to reduce weight and fitted with great capacity fuel tanks and cameras. The longer range and increased altitude required a foolproof oxygen system of sufficient capacity.

Until the beginning of the war oxygen was supplied to aircrew by a system known as constant flow. This meant that while the gas was flowing all the time, it was only being used when the man breathed in; for the rest of the breathing cycle the gas was going to waste. Further, the mask and microphone assembly left much to be desired. The fit was often poor and an inadequate seal on the face led to further leakage and waste. The patient work in decompression chamber and laboratory and the ingenuity of Matthews and his team at Farnborough eventually produced an economical system of oxygen supply. Indeed it was called and is still known as the Economiser. This equipment supplied oxygen through a regulator from cylinders; it only released the gas when the man breathed in and, if for any reason such as shock or unconsciousness the breathing became shallow, the pressure would increase enough to open the valve and give a supply automatically. At the same time the face masks were being improved to prevent leaking around the sides. The economiser system, developed by the physiologists and made in the first incidence by engineers of the R.A.E., more than doubled the range of the first reconnaisance aircraft for the amount of oxygen that could be carried. This important piece of work confirmed the place of aviation medicine in support of operational flying.

Alongside the development of practical flying equipment, went the research into the effects of oxygen lack at various altitudes. The pressure in the chamber could be varied to simulate heights from ground level up to 60,000 feet. It was fitted with intercom and oxygen supply and the effects on the subjects could be observed by those outside. The doctors, some acting as subjects and others as observers, studied the effects of oxygen lack at different heights and under different circumstances.

To resolve a problem it is necessary to study every facet of that problem and so, at Farnborough, numerous 'runs' were made in the decompression chamber. The euphoria or carefree elation in the first stages of anoxia, which is so like the early effects of alcohol, the sometimes violent actions and uncontrollable outbursts of laughter or abuse and, finally, after progressive weakness of the limbs and failure to speak or think rationally, unconsciousness—all these effects were observed almost daily. It was a sobering thought that any or all these symptoms could take place without a pilot or aircrew realising that there was anything amiss; the medical branch realised that no small part of its job would be the teaching of aircrew. The fact that in so many cases there was no pain or other warning of approaching disaster was what made the lack of oxygen a killer. Aircrew had to be convinced for their own safety that the danger was real. Various tests of performance were set up in the chamber; not only for research reasons but for demonstration purposes. Aiming a Vickers gun, recorded electrically, placing ball bearings in slots, and mathematical and writing tests, were used to show how performance deteriorated as the altitude rose and oxygen became scarcer.

The usual plan of a training run was that half the subjects would have their oxygen turned on throughout the run and the others, while wearing their oxygen masks, would have theirs turned off. All were asked to perform one or other of the various tests and, as altitude in the chamber rose steadily up to say 25,000 feet, those with oxygen could observe the sometimes extraordinary antics of those without. When the doctor in charge outside the chamber thought that anyone was becoming too anoxic, he would order one of the others to turn on the oxygen for him. His astonishment, on recovering from his bemused state, at his unreadable scrawl or failure to do a simple sum and, quite often, the discovery that he was no longer wearing his trousers which the others had removed without his knowledge—all this was always good for a laugh and, more than any amount of lecturing, forced home the need for oxygen at altitude. The run was then repeated so that the unfortunates on the first ascent could have a little gentle revenge on the others during the second climb.

Despite the marked improvement in the oxygen mask the inevitable snag occurred. As always, in the development of any new equipment, though the ideal is striven for it is very seldom reached. Medical officers and others in their work with the high altitude aircraft reported that suddenly the oxygen supply would cut out. It was thought that the mask was at fault, and, in all probability, was due to freezing of one of the valves. The danger to the pilots was evident and a solution to the problem urgent. The laboratory in those days was sparsely equipped and had not a decompression chamber in which the temperature could be lowered to that found at thirty to forty thousand feet. The laboratory staff fitted up a mock cockpit in the decompression chamber which was then surrounded with blocks of dry ice. Using similar oxygen equipment and face masks to those of the pilots on operations they made many ascents, waiting for the emergency to occur as it had done in the air. Eventually the fault was exposed, and proved to be a concretion of ice lodged in the valve through which the oxygen was admitted. This prevented the flow and the wearer was left suddenly at extreme height with less than half a minute to unconsciousness. Serious as this might be in the chamber, it constituted a 'killer' to the pilots on operation. Modifications were made to the mask and it was re-tested repeatedly in the decompression chamber. The resulting re-designed mask was a success and one more problem had been overcome.

The arrival from the U.S.A. of the first Flying Fortresses late in 1940 posed further problems for those working on the hazards of high altitude flying. As always in this sphere the main consideration was the supply of oxygen, but at the heights at which it was proposed the Fortresses should carry out high level day bombing the intense cold and the 'bends' or decompression sickness presented new dangers. Very briefly, 'bends' or 'chokes' are caused by the formation of gas bubbles in the body tissues and fluids, due to the decrease in barometric pressure at high altitudes. The most common symptom is pain around one or a number of joints which can vary from a slight ache to an agony which is completely incapacitating. Other symptoms are itching or pricking of the skin, like the stinging of thousands of ants, and, more rarely, pain in nerves, convulsions, paralysis and fainting. The 'chokes' was so called because the most infrequent symptom of the sickness is a burning or stabbing in the chest with coughing and spitting. The tissues of the body most likely to be affected by the gas bubbles are the sinews around the joints and fat deposits.

The aircrew of the Fortresses of 90 Squadron stationed at Polebrook were very carefully selected and had to be young, if possible not more than twenty four, slimly built and remarkably fit. Further, they had to undergo a test in the decompression chamber, at Farnborough, staying at an altitude between 32,000 feet and 35,000 feet for four hours to exclude those who were susceptible to 'bends.'

The first line of defence against the illness that could assail them at high altitude was the station and squadron medical officers. These two doctors, still serving in the R.A.F. and both with distinguished careers in aviation medicine, did a fine job of work for 90 Squadron. They not only meticulously briefed the crews on oxygen lack, the cold and bends, and demonstrated and explained the use of the oxygen masks and systems, the use of the emergency oxygen sets and electrically heated suits, but flew with them on a large number of the sorties. In the air they observed the amount of work done by each crew member, tracked down faults in the masks and oxygen flow meters, and noted how often and under what circumstances the oxygen masks iced up. The squadron medical officer also flew with the crews on detachment at Kinloss and eventually, went with the Fortresses to North Africa.

An operational flight of four Fortresses which took place in September 1941 instances, not only what bomber crews had to contend with when successfully intercepted by enemy fighters, but also how essential it is that the oxygen system is as near foolproof as possible and crews soundly educated in its use.

They took off from Kinloss, their intention being to bomb the Admiral von Scheer then lying in the harbour of Oslo. They were to climb steadily and arrive over their target at approximately 26,000 feet from which height they would release their bombs. Out over the North Sea only three of the aircraft were in formation, the fourth having taken off five minutes later than the others. When over Norway in loose formation they were attacked by German fighters, Messerschmidt 109's. One Fortress crew realising that interception by a very strong opposition was inevitable, managed to get back to base undamaged. The second was quickly shot down and dived into the ground and blew up. No one was seen to bail out. The third aircraft had been flying in the loose formation about four miles behind the one that was shot down and the captain saw clearly all that had happened. He immediately ordered all crew members to have their parachutes ready and opening his throttle climbed at 1,200 feet a minute with his four engines at full power. On the way up they jettisoned their bomb load and on reaching 35,000 feet turned for home.

It was then that the first of their troubles started. At such an altitude there is a tendency for the voice to become indistinct over the intercommunication system, due to the failure of the vocal cords to vibrate sufficiently in the rarefied air. This fact, and the general strain of the moment, caused one of the two rear gunners to misunderstand an order. He disconnected his oxygen mask tube from the main supply and attached it to his emergency portable bottle. This only lasts a short time and in a few minutes his companion saw the airgunner collapse, fall to the floor and turn blue; his oxygen was finished. Going at once to the rescue he in turn in the tenseness of their position failed to plug into his portable bottle correctly and within a matter of seconds he too collapsed.

For fifteen minutes the captain flew the Fortress, headed for base, oblivious of the fact that his two rear gunners were lying unconscious in the back. At last trying to contact them with no success he was told by the wireless operator that they had both passed out and were lying on the floor. The pilot hastily ‘stuffed’ the nose of the aircraft down and descended at over 2,000 feet a minute. At 29,000 feet trouble multiplied. With no rear gunners they were attacked by a German fighter from no more than 50 yards astern who fired a ten second burst. Both unconscious gunners were hit. One had fragments through both his legs. A main artery was severed and he bled copiously and soon died of the haemorrhage. The other was wounded in the hand.

In the wireless operator’s cabin a piece of cannon shell had shattered the oxygen pipe and soon he also was unconscious. The glycol system was damaged and the cabin was filled with a dense white smoke which blinded the occupants. One of the crew resourcefully jettisoned the perspex dome through which the navigator normally took 'shots' of the stars or the sun for their position. The smoke cleared and then in this series of calamities came the first piece of luck. The Messerschmidt 109 broke off the attack thinking the aircraft was on fire and out of control.

The unfortunate captain found himself badly placed to limp home. One engine was already stopped. The aircraft had been seriously damaged and the aileron controls shot away. He was left with rudder and elevator control. Every time a wing dropped he had to straighten the aircraft by use of the engines on that side. The bomb doors obstinately refused to close and that meant they must be wound shut by hand. One of the crew, taking his portable oxygen bottle, walked through the 'cat walk' to the wireless operator's cabin to collect the winding handle. Back in the pilot's compartment he started to wind the doors in. But very soon the bottle was finished and he collapsed. The second pilot connected the gunner to another bottle and he soon recovered. The second pilot stayed on the main oxygen supply and completed the closing of the doors as far as they would go. But for such extreme exertion as this operation needed the economiser did not provide sufficient flow of oxygen and he fainted. Recovering fairly quickly after the exercise had ceased, he returned to his seat. The pilot succeeded in getting his aircraft home and crash landed in Kinloss with only two of his four engines still running.

It is evident from this story what part oxygen plays in operational flying. Had the two gunners been conscious and manning their guns it is doubtful if the enemy fighter could have got close enough to have done any or as much damage as he did.

From the experiences of the two doctors and those of the Fortress crews at Polebrook, the Squadron Leader compiled a masterly report. One of his strongest recommendations was that crews should not be called upon to complete more than two high altitude sorties a week. It had been noticed that crews tended to become lethargic and irritable after flying above 30,000 feet, too often or too long. Unfortunately shortage of trained crews often resulted in high altitude flights being made several days running. While giving his impression that it would be possible to operate a bomber successfully up to 35,000 feet, the Squadron Leader maintained that above that height a pressure cabin would be necessary. In the general recommendations of the report it is particularly stressed that crews should be warm and at rest.

The very low cabin temperatures, recorded on all the flights of the Fortresses, definitely affected the efficiency of the aircrew.

In the damaged aircraft that managed to struggle back from Norway, there were several incidents that showed that excessive exercise quickly caused collapse even if the subject was connected to the main oxygen supply.

It was further recommended that the guns should be in turrets and automatically fed with ammunition to avoid the lifting of heavy pans of cannon shells. Intercommunication at high altitude should be watched carefully and orders repeated twice and acknowledged clearly, especially in times of emergency. The report finished up by reiterating emphatically that the correct oxygen drill should be drummed into the crews. A very close liaison had been kept during the whole period and regular high altitude reports went from Polebrook to those working at Farnborough.

During 1941, one of the Farnborough doctors, who before taking up medicine was a chemical engineer, was busily testing a piece of machinery for the production of oxygen in flight. The constant struggle was to provide enough oxygen for the ever lengthening sorties of the bombers and at the same time to keep down the weight of the gas cylinders. The machine tried was worked by compressing the air until liquid and then fractionating the result to separate the liquid oxygen from the nitrogen. It worked very well but was a massive contrivance weighing nearly 500 lbs. It was nicknamed the 'Ice Cream Machine.'

The aircraft in which the 'Ice Cream Machine' was installed was the second prototype Wellington which, with no gun turrets and a peculiarly shaped nose, was quite unlike the familiar shape of the Wellington 'Wimpey' bomber. I mention the unorthodox appearance for it has a bearing on what occurred on the last of the twenty odd flights that the oxygen machine made.

The Wellington took off from Farnborough in poor weather with the doctor, and an observer from the firm who made the machine, on board. They were to climb to as great a height as possible to give the 'Ice Cream Machine' a trial at high altitude. The aircraft managed to reach 29,500 feet which must then have been near the record for Wellington bombers.

In the middle of the testing their radio failed and, being above cloud with no radio bearings, became lost. They managed eventually to descend through a small gap in the clouds and came in visual contact with the ground again. Visibility was poor and after doing a square search to fix their position and failing to recognise any landmarks the pilot decided to make a forced landing. He made a good approach to a field through the misty haze of the winter afternoon and tried a wheels down landing. The ground was rough and on touching down the undercarriage broke off. The Wellington finally slithered to a standstill on its belly with much damage to the aircraft but fortunately none to the occupants. The doctor recalls their amusement at the imperturbable look of the stolid 'Ice Cream Machine' as it sat unscathed amongst the wreckage.

As is usual at any accident a crowd soon gathered as if by magic out the ground. But on this occasion they were neither friendly nor helpful. It was the strange shape of the aircraft that convinced them that it must be an enemy machine. No amount of explanation was accepted and the doctor and his crew were firmly marched off to the nearest police station and locked in the cells. It was only after many hours had passed and innumerable long distance telephone calls had been made that their bonafide was established and they were released.

The solution of some of the original problems of oxygen supply did not mean that no further work was necessary. Research and development went on constantly in the laboratory and the air. No chapter on the subject of oxygen lack would be complete without a brief record of the invaluable work of Dr. J. C. Gilson and Miss Margaret Worthington. Dr. Gilson arrived at Farnborough in October 1940. He was from Cambridge and came to the 'Lab' via the London Hospital. He was at once put on to the problems of oxygen supply with particular reference to the masks. His forte and value in this work was his quality of taking infinite pains. He was largely responsible for the modification to the masks that had become necessary in the light of experience on the Flying Fortresses.

Working with him on these problems was a remarkable young woman scientist. She was Miss Margaret Worthington, daughter of an Ear, Nose and Throat Surgeon and herself a graduate of Cambridge University. She delighted in flying and had other unusual talents. Apart from her scientific interest she was a skilled water colour artist and had exhibited. She drove a Frazer Nash car on which, unlike most women, she proved herself a thoroughly practical engineer, doing all the repairs and refinements herself.

These physiologists' work involved a large amount of test flying in Harrows, Wellingtons and later Lancasters. It was necessary to build up exact information on the volume of oxygen consumed by various members of an aircraft crew, when they were performing their allotted tasks. They would imitate the actions and work performed in the decompression chamber and in the air to ascertain the consumption rate necessary to prevent the symptoms of oxygen lack. New pieces of equipment and oxygen systems had to be tested to see if they supplied the crews' requirements.

Gilson was all the time changing and improving the oxygen mask, devising means of avoiding the formation of ice in the valves, and reducing the size of the mask to improve the pilots' and crews' vision. One of Miss Worthington's most valuable contributions was her introduction of an automatic device for measuring the rate and amount of ventilation of a pilot's lungs in a single seater fighter aircraft.

Some time in 1943, over the Egyptian Delta, there appeared enemy aircraft flying higher than ever before. Vapour trails were seen at altitudes estimated to be above 45,000 feet, higher than was possible for any of our aircraft. These aircraft were the Ju86P and their pilots were fully protected by a pressurised cabin. It was vital to attempt some interceptions. Spitfire Mk. V's were specially lightened and installed with only one gun. Pilots were selected, who were least susceptible to bends, and for their physical fitness. This had the desired effect and a South African pilot managed to shoot down one of the Ju86's. To do so he had to get to 43,000 feet, where, despite the onset of severe bends and dizziness from insufficient oxygen, he carried out the successful attack. Lending further spur to the efforts of those in the 'Lab' on this problem of very high altitude flying was the appearance of Ju86's over England. This was even more serious than their excursions over Egypt for they were able to photograph at will the preparations for D day. At all cost they had to be stopped. Two squadrons of Spitfire 9's were specially prepared to meet the threat, but there still remained the probability of a high incidence of bends and anoxia.

One of the studies carried out at Farnborough was an endeavour to reduce the acute pains in the belly which arose from the gas distended bowels. Various diets were tried, excluding such foods as peas, beans, cabbage and other notoriously 'musical' foods. The result was the reverse of that intended, for by leaving out the 'roughage' and 'bulk' of the well-known advertisement, the aircrew became constipated and even more 'windy.' The crew returned hastily to a normal diet and the study in dietetics was quietly forgotten.

The formation of these two special squadrons had the desired effect, for after one or two successful interceptions, the threat of the Ju86's died out. This, however, did not remove the need for our pilots of the photographic reconnaisance squadrons to fly at extreme altitudes. As unarmed aircraft, in their onerous duty of bringing back the pictorial information on which were based the Bomber Command attacks and our preparations for the invasion, their only defence was height. In the absence of pressure cabins or some sort of full pressure suit the only protection against 'bends' was careful selection of the crews, as was the case in the Fortress story. But there still remained the danger of lack of oxygen. At heights over 37,000 feet the decrease in barometric pressure is such that even on hundred per cent oxygen the pressure in the lungs is too low to force the gas into solution in the blood.

Late in 1943 the Flying Personnel Research Committee invited a Professor H. C. Bazett to England to work in the laboratories at Farnborough. He was truly one of the most remarkable men in the sphere of aviation medicine in the last war. A British physiologist who had worked with the great Sir Charles Sheridan at Oxford, he emigrated to the United States in the early 1920's and settled at the University of Pennsylvania. He has been described to me by one of his close associates as a man of enormous patriotism, in fact a dual patriotism to this country and America, carried to the length of paying dual income tax. At the outbreak of war, by no means a young man, he had done considerable research on the condition of the blood and respiratory problems. When the Canadians formed their department of Defence Research he was invited to work on these lines at the Banting and Best Institute. Both these doctors were outstanding in physiological research, Dr. Banting of course, being world-famous for his discovery of Insulin and its treatment of diabetes. Sadly, he was lost to the world of medicine when the aircraft in which he was flying to this country during the war never arrived.

While Dr. Bazett was in Toronto, preoccupied mainly with the problem of living at great altitudes, he conceived the idea of 'pressure breathing.' The direction in which his thought tended was towards a compensation for the lack of pressure in the lungs; that is, if the pressure at these heights was not enough to saturate the blood cells with oxygen through the membranes of lungs then it must be increased. He achieved this by breathing out of the oxygen mask against a predetermined positive pressure. Because this increase in pressure inside the lungs would make breathing a laborious and difficult process, he applied a counter pressure to the chest in the form of a waistcoat, which was pressurised by the oxygen supply into bladders in the garment and, at the same time, acted as a reservoir of supply to the oxygen mask. Working on similar lines was Mr. Gagge at the Aero Medical Centre at Wright Field, Dayton, Ohio. Gagge, a scientist from Yale University, used the same principle but without the waistcoat. These two men worked together in the laboratories and chambers at Farnborough. The task of developing pressure breathing equipment was naturally of importance. It was certain that this equipment which would enable pilots to fly at 44,000 feet for half an hour would give them the edge over the German defences. The work of photographing enemy positions and supply lines was vital to the planners of the invasion of Europe. Later the same squadrons, protected at these great heights by the equipment first thought of by Professor Bazett, were able to pin point the launching sites of the V1 and V2 missiles, which might well have turned the tide in Germany's favour if they had not been constantly attacked by our bombers.

Dr. Bazett was a man of complete scientific integrity, imbued with the idea of the well-being of aircrew. Over sixty years of age and not in good health, he took a major part in all the experiments in the decompression chamber. Although he had already suffered a coronary heart attack in the human centrifuge in Canada, he would persist in trying out his equipment at 50,000 feet, often breathing against a pressure of a pound per square inch. This total disregard for his own safety and comfort continued in his work after the war. One of my colleagues recalls that the last time he met Bazett in 1948 the professor was unable to shake hands. The reason was that he still had a broken-off piece of catheter in the large brachial artery of his right arm, a result of one of his numerous experiments on blood circulation. He later had to undergo an operation for the removal of the offending object. This experiment, like so many before, was on behalf of those who fly, in this instance the crews of the United States Air Force.

Professor Bazett, patriot and brilliant scientist, was a true adventurer along the obscure and sometimes dangerous paths of physiology. The value of his work in the realms of high altitude flying is incalculable. He succumbed at last to another coronary attack, dying en route to England to pay a visit to one of his two Mother countries.

At the end of 1946 only a small number of the wartime staff remained but these few had the background of the years of research and experiment. They were able to meet the new challenge with the help of brilliant young research workers who joined the staff either through the medium of national service or permanently. A new era in aviation medicine had begun. As each advance in aircraft and engine design had brought with it new medical problems, so the age of jet, ram jet and rocket engines exposed aircrew to the greater hazards of exploration in the upper layers of the atmosphere. The ever thinning air of the altitude contemplated, demanded persistent endeavour in the development of more efficient oxygen systems.

The change in flying conditions led to a different set of requirements which the old wartime pressurised system could not provide. This was shown by experiments in the decompression chamber at the greater altitudes. Pressure cabins were becoming more common in military aircraft, but were far from perfect. Pressure could be lost slowly and insidiously by failure of certain seals, or more commonly, explosively, by shattering of the perspex canopy which is liable to become somewhat brittle when exposed to low temperatures. In the event of this emergency, loss of cabin pressure, the pilot and aircrew might be exposed to external conditions as high as 48,000—50,000 feet. The system devised by Professor Bazett and his co-workers, by providing a pressure in the mask and lungs of a quarter of a pound per square inch, protected the man at altitudes around

44,000 feet. As the altimeters crept nearer to the 50,000 feet mark this pressure became insufficient and lack of oxygen and unconsciousness again became a real danger. In order to make a safe descent from altitudes of this order after losing cabin pressure, it was found after much experiment and runs in the decompression chamber, that the mask and lungs would need to be supercharged to nearly half a pound per square inch. Colonel A. P. Gagge, doyen of American research in aviation physiology after General M. G. Armstrong had left this field, is largely responsible for the development of the system which does provide the necessary protection. Quite simply it consists of a regulator mounted in the cockpit which, on exposure to altitudes above 40,000 feet, automatically ensures that the lungs, through oxygen mask, are pressurised sufficiently to ensure full absorption of oxygen by the blood. Further with this system the wearing of a waistcoat, as in Bazett's method, becomes unnecessary. Excellent though the demand system is as a protection at the altitudes quoted, it is only a temporary expedient and remains a 'get you down' procedure only. With the lungs pressurised alone, pressure breathing is an acquired aptitude and for this reason and owing to the tendency of the blood to pool in the limbs and other unpressurised parts of the body, fainting can occur after very few minutes. Pressurised breathing to half a pound per square inch was no protection against the hazard of sudden loss of cabin pressure above 50,000 feet and so a new era of investigation and development came into being which taxed physical vigour as well as ingenuity and technical knowledge to the full.

As consciousness was lost, even when breathing pure oxygen, if the pressure was inadequate, the only possible remedy lay in restoring pressure to a suitable degree, in fact to the equivalent of that at about 40,000 feet. Instead of less than a quarter of a pound per square inch, pressures up to two pounds might be required. The requirement brought with it further problems. It can be readily understood that if such a pressure was applied to the head only, no blood would reach the brain, since the average pressure in the

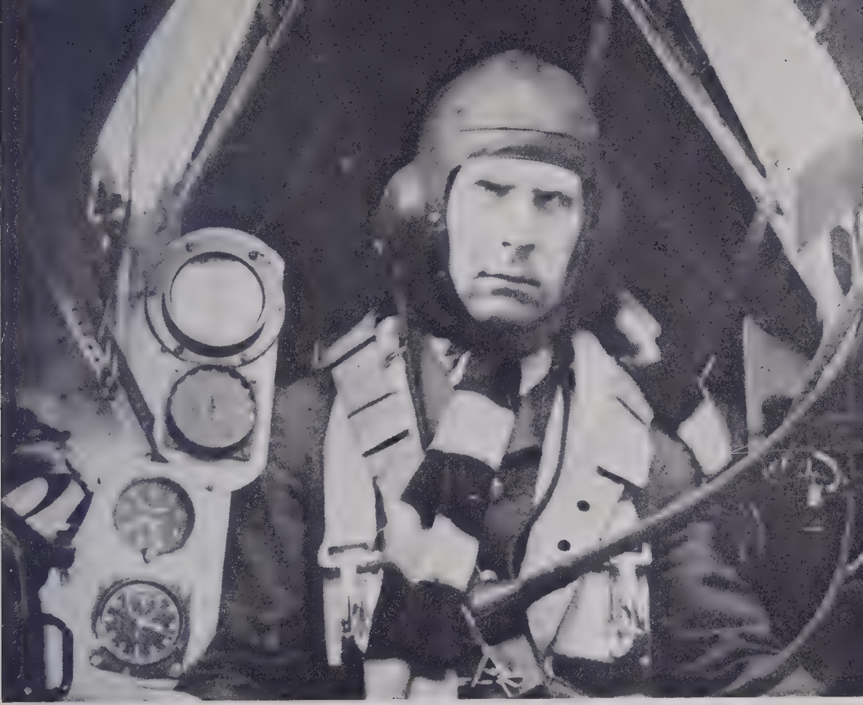
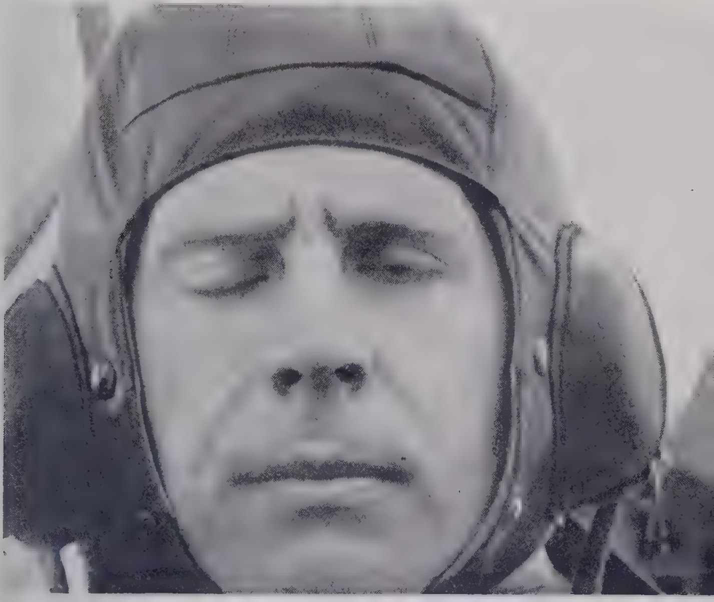


PLATE 6

The effect of 'G' in a spiral dive in the Battle aircraft.
Above—'Blacking-out'. The recording instruments are on the left.
Below—Unconscious.



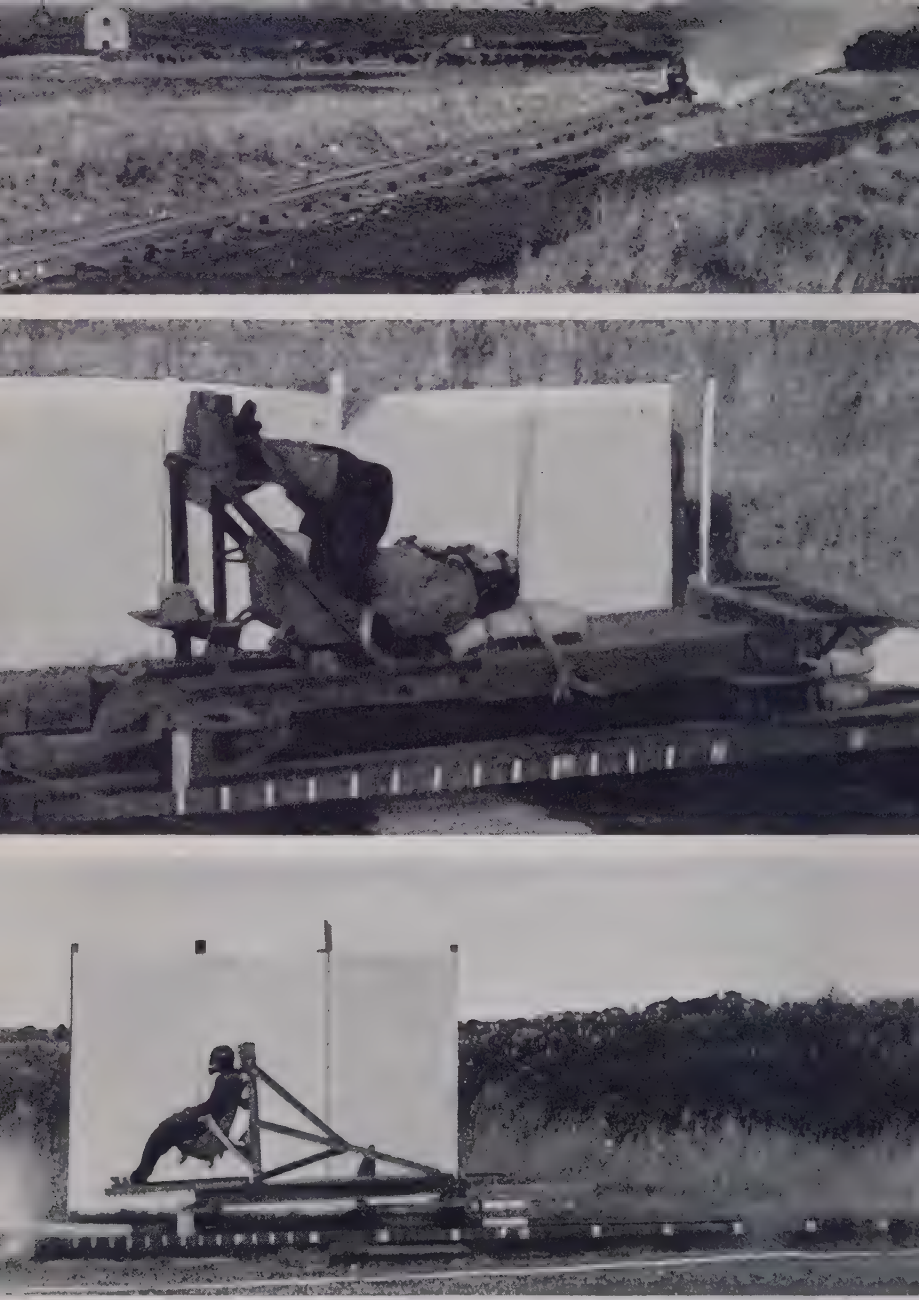


PLATE 7
Experiments on the Rocket Track. Work on the physiology of ejection (the effects on the spine of violent acceleration) and on the support given to the spine in the event of a crash by backward-facing seats (now generally adopted in Service transport aircraft).

arteries is of the same order. If applied to the chest and lungs alone, since the pressure in the veins returning the blood to the heart is extremely low, that organ and the brain in turn would be robbed of blood and fainting would again occur. In 1944 Professor Bazett had already foreseen this situation and carried out experiments on himself in the Farnborough decompression chamber at 50,000 feet. He wore what was available at that time to aid the return of blood to his heart, one of his own pressure breathing waistcoats and an original water filled anti-G suit—the Franks flying suit. Even though normally subject to heart attacks he managed to stay for over twenty minutes at this pressure and descend without incident.

This work was followed up by Dr. J. P. Henry at the University of South California after the war. Dr. Henry, one of America's foremost physiologists is a graduate of Cambridge University. He developed this idea further and as a result of his research a more modern pressure suit evolved which has been used extensively in America and Britain. Fabricated most ingeniously in nylon and worn as a skin-tight undergarment, this partial pressure suit, so called because the hands and feet were not included, was at an early stage assessed at the Institute of Aviation Medicine. When applying pressure of this order to the body it was found necessary to prevent damage to eyes and ears by enclosing the head in a pressurised helmet. When this was devised it was then feasible to carry out a full programme of evaluation of the suit and helmet. It had to be discovered for what length of time the suit could be worn and how long the discomfort of the unpressurised extremities could be tolerated. The hand particularly could become grossly puffy and the fingers like a bunch of sausages. On every run of the decompression chamber safety medical officers stood by to deal immediately with any collapse or other unforeseen emergency. This work, not without pain and discomfort to members of the staff, had also its amusing moments. If the suit fitted badly the areas without adequate pressure might show evidence of the high unsupported pressure in the small blood vessels by numerous small points of bleeding into the skin. This happened on one occasion on the top of the balding head of a test pilot, much to his obvious embarrassment.

And so the work goes on. Every year brings with it the possibility of ever increasing altitudes. Pressure suits to protect man against failure of his pressure cabin become more complex as the higher altitude requires a greater pressure in the suit and helmet. The task of physiologists and engineers is by no means as simple as the splendid space garments of the ingenious artists of the comic papers would indicate. If the regions of the ultimately thin air and unbelievable cold are to be conquered by man, then he must take with him an atmosphere and climate in which his body can live. The complexity and solution of this problem is indeed one of the main preoccupations of those in the field of aviation medicine.

3

‘*G*’

SWISHING round a corner in a fast sports car one is pressed to one side; riding in the flying chairs at a fair as they whirl higher and faster one is pressed further and further into the seat. But when the speeds are doubled or trebled, as in fighter aircraft in a turn, the exhilaration fades and the manœuvre can lead to temporary blindness and unconsciousness. Violent changes of direction and the tight turns of ‘dog fighting’ became more common with the increasing activity of the Luftwaffe bombers with fighter escort coming over in daylight, and consequently the Battle of Britain pilots began to experience these blackouts frequently. The number of times the force of gravity is multiplied and imposed on both man and machine increases with the speed and with the ‘tightness’ of the turn. The effect of this is to multiply the weight of everything so subjected by the number of ‘Gs’ applied. The pilot’s body is forced into his seat, movement of head, arms and legs becomes leaden and the soft tissues of the face are dragged downwards in a bulldog-like scowl. All this, while uncomfortable and an encumbrance to flying, is insignificant in comparison to the effect the ‘G’ has on the blood. As well as becoming four or five times its normal weight, naturally as a fluid it drains, as any fluid would, from the upper to the lower half of the body and it is this robbery of the blood supply to the brain that leads to mistiness of vision, or ‘grey-out,’ blindness or ‘blackout’ and finally unconsciousness. This then was one of the urgent problems in the early stages of war that needed a quick answer.

The project was handled by a young Scots physiologist who had been working at the National Hospital for Nervous Diseases in Queen's Square and had joined the laboratory in the early months of the war. In January of 1940 a Fairey 'Battle' and a pilot were allocated to the 'Lab.' This was the first of an imposing array of aircraft to be used and flown by the physiologists and doctor pilots. The 'Battle' was carefully instrumented to show the amount of 'G' imposed, the time and the airspeed. This information and the physical effects on the subject were automatically recorded by a cine camera. The first task of the pilot, and the doctor as subject, was to find a safe manœuvre which would give a constant value of 'G' for a given time. The margin was fairly narrow as the structural limit of the 'Battle' was 6 'G,' above which the aircraft would begin to break up.

After trying all the aerobatics in the book, they finally settled on a diving spiral. The point of the constant value of centrifugal force for a given time was to find out the various times that it took for the subject to 'grey-out,' to 'black-out' and to lose consciousness. This information was to be found in German and Dutch medical literature, but had to be proved, for the Germans particularly might well have falsified their figures to mislead a future enemy. The photographs of the early sorties in the 'Battle' were the first ever taken to show the effects on a person subjected to increased 'G.' As the aircraft flew downwards into the spiral dive the film recorded how the doctor was pressed down into his seat as if by an unseen weight on his head, the muscles of his face were dragged down into senile folds, and eventually his eyes glazed and then closed as he passed into the inevitable faint.

He describes graphically his recovery from unconsciousness on one of the memorable flights that this team made together. He recalls his surprise on coming to as the aircraft straightened out and the leaden force of the spiral was removed. Bemused at first, he thought he was in heaven until, realising he was in an aircraft cockpit, he found that he had slipped out of his safety harness and seat and was on the floor. He noticed that clear fluid was draining from his nose and his mental confusion led him to believe that it was cerebral-spinal fluid from his brain, but it was in reality fluid from his nose and sinuses flowing down, as the blood in his vessels had rushed from his brain and caused the blindness and unconsciousness.

When sufficient information had been obtained on the amount of 'G' and for how many seconds it could be tolerated without men blacking out, it was time to think of methods of protection. Some time before the war, tight belts around the stomach had been tried without much success. These were again tried in the 'Battle' and proved to be no use. Experimentally, tourniquets were fastened on the doctor's legs to prevent the blood draining into the lower limbs. From all these trials and flights it was found that quite considerable protection was afforded by adopting a crouching position to tense the belly muscles, and by raising the legs. Higher values of 'G' could be taken before the subject blacked out.

Several sets of special rudder bars with a high and low position for the feet were made at the R.A.E. and tried out first on a Gladiator and later on Hurricanes and Spitfires. These were tried by many distinguished fighter pilots, and they all strongly approved of the method of protection. This patient and sometimes hazardous work resulted in the modification of all fighter aircraft rudder bars.

It is unfortunately impossible to assess the number of lives that were saved by the work of the Farnborough team in this field. The physiologist and his pilot made three hundred flights and, on no less than two hundred occasions, the young Scottish doctor experienced the symptoms of blacking out and fainting.

It was evident to the Air Forces of the warring nations that the ability of pilots to tolerate high 'G' might prove a vital factor in the battle for air supremacy. Fighter aircraft were rapidly improving in speed and performance and it appeared that more protection would be required than by the crouching position and raising the feet. It was thought that the Germans, who had experimented with a water suit in 1938, would almost certainly be doing their utmost to solve the problem. Looking ahead to the inevitable clash that must come on the continent, the Allies realised that they must have better or at least equal protection for their pilots.

In the spring of 1941, Squadron Leader W. R. Franks of the R.C.A.F. Medical Branch, arrived at the 'Lab' from Canada. He had devised a suit of heavy cotton fabric lined with rubber which fitted the body from the heart level downwards. This could be filled with water which, when acted on by 'G,' would apply pressure on the trunk and lower limbs and so prevent the usual draining of the blood to those areas. The doctor who had been the subject for blackouts in the Fairey Battle worked with Squadron Leader Franks on this project to test and measure the amount of protection which the suit gave. The Fleet Air Arm tried the suit and liked it, not only because it prevented blackouts and the fatigue of the repeated 'G' of violent manœuvres, but because the two gallons of water it contained would be of value should men have to spend many days in a dinghy.

In 1942 the authorities, as always, thinking ahead to 'D' day and the invasion decided that if all the Allies' Tactical Air Force pilots were equipped with the suit it might well prove to be a winner. They ordered production in some quantity for more extensive trials and assessment. Many different groups of pilots from the Allied nations tried it out and reported favourably. But the final decision whether to adopt it or not had still to be made. The suit theoretically provided a perfect fluid balance of pressure between the water outside and the blood inside the body, but against this was its considerable weight and the fact that it was undeniably cumbersome. The final decision against its use was probably swayed by an incident that occurred in 1943.

Remembering that the Germans had developed a water suit in 1938 which they had tried out on their man-carrying centrifuge, it seemed certain that they must have in service some kind of 'G' suit. One day in that year a Luftwaffe fighter pilot landed at an airfield in the West country in a

Fockewaffe 190, the latest and fastest of the enemy's fighters. The story was that he had made an error and flown on a reciprocal course, in other words, by mistake, had set north instead of south on his compass and running short of fuel had been obliged to land. This, however, did not explain why he had not destroyed his aircraft to keep the secrets of this latest fighter from the allies. It was known that this was possible, because the newest aircraft always had installed a time-delay explosive charge sufficient to destroy all the secret equipment it might contain. The real reason was, in fact, that the pilot had an English mother and had come over to the allied side.

The capture of such an aircraft was of the utmost importance to the Air Ministry and of particular interest was the pair of special leather breeches worn by the pilot. The question as to whether it was some form of 'G' suit sent two members of the 'Lab' post haste to the airfield to investigate. The trousers turned out to be just what they looked, a pair of leather breeches and no more. From this and other evidence it appeared evident that the Germans had not got a 'G' suit. It was eventually decided that the suit would not be needed as it was felt that, in view of the powerful Tactical Air Force that had been built up, aircraft and pilots would prove more than a match for the Luftwaffe when the great day came.

The Canadians were not alone in this field of research. About the same time as Franks was working on his suit in Canada, Professor F. S. Cotton in Australia had made a rubberised suit which covered the same areas as the Franks suit. It was, however, operated from a compressed air bottle through a gadget nicknamed the 'Pipes of Pan,' which gave graded pressures into the compartments of the suit. The highest pressure being exerted at the lower end and the lowest at the upper end of the suit. Professor Cotton came to the 'Lab' at Farnborough via Canada to bring his suit for trial and experiment.

I understand that, at that time, a rather amusing altercation arose between Canada and Australia as to who was first to produce a 'G' suit that could successfully be used on operations against the enemy. An Australian squadron at Darwen in Northern Australia was equipped with the Cotton suit but it had to be abandoned because of the heat load on the pilots of an impervious rubberised suit worn in the tropics. While testing the suit in the air at Farnborough, one of the medical pilots had an alarming experience. On this particular occasion the 'Pipes of Pan' failed in their function and the whole suit was blown up to the highest pressure. The pain of nearly thirty pounds of pressure to every square inch over nearly the whole of his body almost made him lose control of the aircraft. Fortunately his skill and determination won and he managed to land safely.

The Americans naturally had given a lot of thought to the problem even before they entered the war. As early as 1935 Professor John Fulton of Yale University had produced a simple inflatable suit. Sometime later Poppin, a United States Naval doctor, did some work on abdominal belts used on dogs subjected to 'G' in dive bombers. Their usefulness, as we have seen, was disproved in their trials by the team in the Fairey Battle at Farnborough. Later than Franks or Cotton, Lieutenant Ferwerda, also of the United States Navy, developed a three compartment suit which was run off the instrument pump. From this work, and from that of Dr. Baldes and others at the Mayo Clinic, it emerged that protection was possible from a suit with the same pressure in all the compartments. The Americans went ahead of the rest of the allies and before the war had finished they had a satisfactory anti 'G' suit in service. We finally reversed the early decision not to use the suits and began development on the American lines in 1944.

There are other effects on the body from acceleration than the centrifugal forces I have briefly outlined. Much physiological work was carried out in the development of safety harnesses and methods of escape from aircraft which later led to the medical problems of the ejection seat. Problems in this field became of greater concern with the arrival at the Royal Aircraft Establishment of the first aircraft to be powered by a gas turbine engine.

During the war intensive research had been carried out into the ditching characteristics of every type of aircraft, firstly by means of models and thereafter by study of actual incidents. Safety in crashes on landing and taking off had been the special study of a Czechoslovakian professor of mathematics who had been working in England on leave from his university before the war commenced. In collaboration with members of the 'Lab' staff he expended an immense amount of thought in experimentation, and mathematical treatment in the problem of avoiding injuries from sudden deceleration in crashes on land or sea. Theories of protection were tested, discarded if necessary, and eventually there was sufficient proof of the human body's strength to permit the design of safety harnesses strong enough to withstand crash loads of twenty five times the weight of a two hundred pound man.

Initially the design of these harnesses was tested by applying static loads of a thousand pounds to the back of a human subject seated in a strong rig. In this way it could be determined whether the position of the harness straps could injure such organs as the liver, spleen or the bowels. This problem overcome, a more rigorous test was employed. A trolley was used, mounted on a small railway track, which could be accelerated up to 350 miles an hour by means of batteries of rockets. It was brought to a halt by scoops which engaged in long troughs of water and the final deceleration was effected by a tapering steel ram which engaged in a cylinder, also full of water, positioned underneath the trolley. This apparatus had been used previously for testing cable-cutting devices for the protection of aircraft caught in a balloon barrage. Another experiment, and rather a messy one, involved the use of dead chickens. Low flying aircraft, particularly in the Middle East and Asia, were always in danger from large birds, especially the Kite Hawk, which could in collision shatter the windscreen. The experiment was to send the trolley along the track in a collection of dead fowl hung in the path of the windscreen under test. For the harness tests a strong steel seat was fixed on the trolley floor. The harness to be tested was fastened to the seat and as a precaution another harness of great strength was applied loosely over the top. The intrepid subject from the 'Lab' then entered the seat and all was ready. The trolley was fired off and accelerated up to about eighty miles an hour from some distance away from the ram. This was so that the friction of the wheels on the rails could reduce the speed to that suitable for the final deceleration and resultant strain on the harness. This system was later used in proving the value of backward facing seats in reducing the injuries to passengers in forced landings and crashes.

Escape from aircraft, however, had not been studied in any detail up to this time. The only way out of any aircraft fighter or bomber, was through canopies and hatches which could be jettisoned. Methods of escape and the drill involved were taught by safety officers through the medium of lectures, posters and films. But most thinking pilots had worked out in their own minds what manœuvre they would use if suddenly faced with the need to leave the aircraft in flight. Many were the heated arguments over the advantages of climbing out over the wing, rolling the aircraft and falling out or jamming the stick forward and being shot out of the aircraft. Indeed the frequency with which this last method was used by Germans pilots flying FW 190's against the Normandy invasion gave rise to the tale that these aircraft were fitted with ejection seats.

There were always a small number of miraculous escapes. There was the Typhoon pilot, who attacking a strong point on the coast received a direct hit from the ground defences which destroyed his aircraft to such an extent that he found himself flying through the air at close on 400 m.p.h. attached to his seat. Instead of the certain death he expected he survived uninjured when he landed in soft thick mud. Similarly some bomber aircrew experienced equally miraculous escapes. There was the mid-upper gunner who managed to get out of his turret after his Halifax aircraft had been hit and make his way to the tail end. He 'came to,' still in the same part of the bomber which was lying across a row of railway tracks in a siding. Hard to believe, if it were not verified in this case by German authorities, is the case of the navigator who, after the aircraft exploded at a height of some 10,000 feet, fell freely without a parachute on to the sloping branches of a pine tree and into a snowdrift, and suffered nothing more than a broken leg.

The scientific study of escape did not, however, commence until the fatal accident in which the pilot of the prototype Meteor lost his life. The circumstances were such as to initiate the first detailed medical investigation in which forensic science or the Scotland Yard technique of post mortem examination was applied to discover the course of events. The results of the enquiry instigated work on assisted methods of escape from aircraft. The major lesson learnt by the investigators was the impossibility of leaving an aircraft at the high speeds of the new jet era by any of the old methods. Either the wind velocity would deny exit from the cockpit or, if the pilot got out, would sweep him on to the tail of the aircraft and to certain destruction.

During 1944 various investigations were made into the best methods of escape. Controlled disintegration of the aircraft, the use of parachutes released from the tail to slow down the aircraft's forward speed; sideways escape, or turning the seat and pilot upside down and throwing him down a chute, were some of the methods explored. But after all the work involved it was concluded that upward ejection was the best method. Into the picture came the aerodynamacists who declared that an acceleration of twelve times the force of gravity or 12 'G' applied to a seat, and of course in effect, to the pilot's bottom, would produce an upwards velocity of 40 feet per second, sufficient to clear the tail of an aircraft travelling at high speed.

At this time nothing was known of the strength of the human spine. Would such forces kill the pilot or merely break his back? All that could be intelligently guessed was that the time was too short to displace blood and body fluids seriously and that he was unlikely to become unconscious or suffer concussion. Physiological tests were therefore necessary and once again the 'Lab' staff resorted to personal experience of the rocket track. This time, however, the doctor subject was strapped lying down into the seat so positioned that his rear was facing forward with his legs suitably supported. The test in these experiments was to decide how much the human body could withstand when starting suddenly, rather than the effect of the tremendous brake forces of a crash in the evaluation of safety harnesses. These runs on the rocket track proved that a system of ejection from an aircraft by a cartridge fired ejection seat was indeed feasible and that the pilot would not be incapacitated. They also indicated that at the moment of peak acceleration the sudden forcing of the head forward could be dangerous and some method of control of the head would be necessary. Apart from some after-pain in the neck and small of the back the original subjects from the 'Lab' suffered no ill effects.

During 1945 and 1946 work with the aircraft firms undertaking the development of the ejection seat established two further principles. The trials on an aircraft designed to carry an ejection seat behind the pilot showed conclusively that a seat velocity of at least 60 feet per second was necessary to clear the tail of an aircraft which might be moving at nearly 500 m.p.h. The second point became evident after the development of an ejection test rig, up which a seat could be fired. The gun that operated the seat initially, used the 20 millimetre cartridge propellant which was so strong that it broke sturdy recording apparatus fixed on the seat. Riding the seat up the rig was a shaking and sometimes dangerous experience to those whose back was insufficiently strong. Injuries to the base of the spine were common and it must be recorded, though without malice, that an enthusiastic journalist, avid for copy, and insisting on a ride, ended in hospital with a fracture of one of his vertbrae. Thus it was necessary to slow down the rate of thrust and also to limit the amount of 'G' that was imposed. Some time later a larger rig, 60 feet high, was constructed by one of the firms, and on this the whole cartridge and seat system tested. From the information obtained it was possible for safe limits to be laid down. Alarming as the first ride could be, familiarity bred contempt and many subjects enjoyed riding these rigs, though one of them at Farnborough was less popular. It was only half the necessary height and the rails on which the seat rode were completely vertical instead of being at a suitable angle of 30°. The effect on the unfortunate subject when he came to rest was a ghastly feeling of falling forward. Further, as it was too short for full cartridge charges when these were used the nylon cable of a glider towing winch was attached to the seat. This imposed a constant force and prevented the assembly shooting off the top. It was not unknown for this device to fail, but happily it never failed to any serious extent with human subjects aboard.

In all these tests, discomfort and pain were the chief arbiters of experimental procedure, but high speed cine photography, recording of the gas pressures in the gun, and small electronic accelerometers, all helped to build up a body of information. The ejection characteristics of the survival seat packs also had to be tested. If these had too little damping effect or were too elastic, then the upwards run of the seat would commence by compressing the pack by 2 or 3 inches. As a result the peak force of the acceleration would be landed on the subject's rear suddenly instead of smoothly, and jarring through the spine would be transmitted to the rest of the body.

These seats were fired by pulling a blind down over the head which served to protect the face and helmet and oxygen mask from wind blast. It also prevented sudden bending of the neck and took some of the weight of the arms off the trunk. After the development of a stabilising parachute for the seat, and an automatic streaming of the man's parachute, the seat was ready for the first live ejection. This was carried out by Mr. (Benny) Lynch of the Martin Baker Aircraft Company who had developed the seat. In the years since this work the seat has been made increasingly foolproof and automatic, so that it is only necessary for the pilot to pull down the blind: all the rest is done for him. Live and successful ejections have been made from ground level up to 40,000 feet and from speeds of from 120 m.p.h. to over the speed of sound. Wonderful as the present seats are, work and experiment will have to continue to extend protection to men at the speeds and heights which will undoubtedly be reached by future aircraft.

4

Learning to Fly

I AM prefacing this account of personal experience of flying training and some of its medical aspects, with a brief record of two officers who lost their lives in the course of their work for aviation medicine. Group Captain H. Corner and Squadron Leader D. A. G. Robson, both regular medical officers, had qualified for their wings before the start of the last war. The example of Graeme Anderson and the others in the 1914-18 war who, though doctors, qualified as pilots, created a precedent that became embodied in King Regulations and Air Council Instructions. This regulation encouraged doctors to gain flying experience and authorized the award of pilots' wings after certain conditions had been met. These included sixty hours flying, dual and solo, a height climb to 10,000 feet, and the completion of successful solo cross countries. A considerable number of medical officers had taken advantage of this privilege before the second world war. Wing Commander Hugh Corner was one of these doctors whose enthusiasm carried him beyond the elementary type of aircraft on which he originally qualified. His off-duty delight in owning and driving high powered cars and motor cycles was in character with his interest in the most modern fighters of the time, first the Gladiator and later the Hurricane and Spitfire. He was a handsome man with dark hair and moustache. His photograph still hangs in the Library of the Institute of Aviation Medicine at Farnborough.

At the beginning of the war he was already a senior Wing Commander. He was popular with all who came in contact with him, both for his excellence as a doctor and his own personality. His flying ability and intense interest in working with and for aircrew soon produced a reputation far outside his immediate sphere of influence. His action inspired many of us who were not fortunate enough to meet him to persist in our efforts to obtain our wings. It was not easy or indeed justified in those days of total war to occupy too much of the time of aircraft and instructors. This meant that progress was often slow and disheartening and it was a struggle to build up the necessary number of flying hours.

Corner believed, as did those flying doctors of the first world war, that it was essential to the medical care of aircrew that the doctor should himself fly. With the onset of the Battle of Britain his work became intensified. Despite all the work of visits to the fighter stations, lectures on oxygen, blackouts and flying clothing, he made time to accompany the squadrons into the battle against the Luftwaffe, flying his own aircraft. From the strains and fatigues he experienced himself he was able to make valuable recommendations for the benefit of the fighter pilots. His reports on the dangers of 'blackouts' and on tiredness resulting from repeated exposure to 'G' in the tight turns and 'pullouts' from dives in the daily dogfighting all enhanced the urgency of the work at Farnborough. And above all, the effect on the morale of those with whom he shared a common experience of modern air warfare could have been nothing but good. He surely must be included among those 'first of the few' who sustained and heartened our closely encompassed island.

Until this stage of the war in the air there was very little information as to the amount of flying and battle that pilots could tolerate without becoming weary and strained to the point of inefficiency or breakdown. The number of sorties that could be achieved without loss of health and enthusiasm naturally varied with the individual concerned, and the severity and dangers encountered on those sorties. A pilot who, after a number of flights, had successfully shot down four or five enemy fighters without damage to himself or his plane is more likely to 'press on' happily than perhaps an equally good pilot who had been himself shot down and survived, with no enemy kills to his credit. It was not to the 'aces' that Corner must have given most attention and thought, but to the average pilot and his tolerance to strain and fear. His evidence and opinion on these matters, valid through his own experiences, made it possible to lay down the number of sorties that should make up a tour of operations, after which aircrew should be rested on a less hazardous form of flying.

As deputy to the Principal Medical Officer of Fighter Command, Wing Commander Corner was promoted to Group Captain. This administrative post of some importance, particularly in a large operational command at war, did not keep him out of the air. He continued to fly as regularly as ever with the fighter squadrons. After the Battle of Britain was over and won, fighter aircraft were increasingly sent on sweeps over France and the continent, attacking ground installations, troop concentrations and aerodromes. They had the advantage of surprise, for they travelled at high speeds and at low level. They were also subject to greater opposition from ground defences than had been experienced in the previous high level dogfights. Corner went on many of these sweeps, once again to experience for himself these new conditions and dangers that confronted our fighters.

As he was non-combatant he usually flew as No. 2 of a formation so he could be protected to some extent by his more experienced comrades. One day he again set out with a flight of Spitfires, as usual flying No. 2 to the leader of the formation. On reaching the coast of France the opposition was more than usually severe. The ground defences scored a hit on his aircraft. He broke formation and turned for home. Over the radio he reported to the operations room of his station that he was uninjured but that the aircraft had developed a bad fuel leak. Some little time later he again called up base. His fuel was nearly gone and he was losing height. The operations room staff listened out anxiously until his last message came through. His steady voice said he was baling out. He was never found. Either he left it too late to escape from his plane or he was one of those the Air Sea Rescue men failed to find. So Hugh Corner died. Not in vain or wastefully, for he left behind him an example and tradition which will not be forgotten. He lived and died in the spirit of the motto of the Royal Air Force Medical branch 'Nec Aspera Terrent'—No Hardship Deters.

Squadron Leader D. A. G. Robson joined the R.A.F. before the war and, like many others in the medical branch, had qualified for his wings on elementary type aircraft. An Edinburgh University graduate, he was a fine all-round athlete, excelling particularly in swimming, water polo and tennis, being in fact captain of lawn tennis for his university. Early in the war Robson was the medical officer at Benson where the squadrons of high flying Spitfires were being formed for photographic reconnaisance. His work in the air and on the ground produced recommendations of much value to the laboratory staff at Farnborough who were working on the development of an economical oxygen system. He worked in close liaison with them, reporting faults and failures in the system, and the oxygen masks. Later he was the senior medical officer of West Raynham in Norfolk about the time that the first American B17 Bombers arrived in this country for use in the R.A.F. The role of these flying Fortresses was very high altitude bombing by day, sometimes in formation and sometimes singly. They used special bomb sights and were protected from enemy fighters by their enormous gun power. They attacked such diverse targets as Brest, Heligoland and Bremen, and reached far out to enemy installations and battleships in Norwegian ports.

Robson with his keenness and interest in the problems of high latitude flying, went on some of the first flights made in this country. Some of the problems facing the Fortress crews were to take a lot of solving. An efficient oxygen system had to be worked out, not only for those whose jobs were sedentary in the aircraft, but for those crew members who had to move and do physical work. These would need a greater flow of oxygen to prevent the now more familiar reactions to high altitude.

The other main hazard was the bitter cold at heights of 35,000 feet. In the Fortress the gun ports on the side of the fuselage opened to allow the guns to be swung out, so the crews would be exposed to temperatures which might be as low as −50° centrigrade. For their protection the crews wore, as well as heavy clothing, electrically heated suits, which at that time were bulky and cumbersome and none too reliable. On landing from one of these early flights, Robson reported that he recorded 37° C. of frost in the wireless cabin and 42 degrees of frost in the gunners' cabin. They had climbed to 33,000 feet, where they stayed for 15 minutes.

On this occasion the electrically heated suits all worked well, but the story of the oxygen masks was not so happy. All the masks froze up except those of the pilot and one observer who were in the warmest positions. The intense cold had frozen the water vapour in the expired air and the ice formed, completely closed off the valve. When the expired air was forced out around the sides of the mask, particularly at the sides of the nose, it was blown up over the eyes and ice promptly formed on eyelashes and eyebrows.

In his recommendations on this flight Robson pointed out that whereas this discomfort might be tolerated for a quarter of an hour, it would be a very different story on a flight of four or five hours. The men's eyebrows and eyelashes had frozen despite the mineral oil paste they had smeared on their faces. Robson removed his mask on the descent when it was safe to do so and found the expiratory unit solid with ice. His recommendations went to Farnborough, where modifications were made to the masks to prevent the freezing up.

A short while later Robson went on another trip, accompanied this time by a member of the 'Lab' staff, to try out the modified masks. It was to be his last flight.

I am indebted for the story of this tragic flight to the other doctor. The Fortress took off on a non-operational test to fly north to the Shetlands and to return down the North Sea. When at 32,000 feet over Catterick the aircraft flew into the top of a thundercloud. In these cumulo nimbus clouds the up and down currents of air can be extremely violent, sometimes reaching 100 m.p.h. The great turbulence of these conditions threw the heavy aircraft about the sky as easily as a cork on the waves. The pilot failed to maintain control and in a few seconds the bomber was in a spiral dive. The centrifugal force of the spiral glued the crew to their positions. So great was the amount of 'G' on the aircraft that it began to break up. First one wing, then the other broke off, and finally the cockpit parted from the rest of the fuselage. Separated from their oxygen supply those in the back were in a parlous condition. The doctor from Farnborough found himself on the other side of the fuselage and he thinks he must have passed out for a moment with no oxygen. He remembers seeing the tail end at a steep angle above him. He was so weak and dazed that he had not realised that the front end had disappeared. His one thought was to get out. Struggling up towards the tail, clipping on his parachute pack as he went, he found Robson, practically helpless and nearly unconscious, trying to get out on the starboard side through a space between the gun and the edge of the gun post. He managed to manœuvre Robson through the gap and then get out himself on the other side of the gun. This gallant action was of no avail, for Robson must have been too far gone to pull his parachute ripcords and it never opened. The doctor landed safely and was the only survivor of the crew of eight, and later was awarded the Air Force Cross.

The Director General of Medical Services, Air Marshal Sir Harold Whittingham, had for some time envisaged a full course in pilot training for a limited number of his medical officers. This was to be in no way a special course and the doctors were to receive the same training from start to finish as the general duties operational aircrew. At last in the latter half of 1942 letters went out from Air Ministry to Commands and Groups, stating that up to twelve medical officers a year were to be selected for flying training duties. I have no idea how many applications the Air Ministry received, but if they went in as quickly as mine there must have been quite a flood! At the time I thought that I did not stand much chance as I had already got my wings under the old scheme, on the Ansons we had on the station. To my surprise, however, six months later in March of 1943, I was posted to Aircrew Reception Centre, Regents Park. Here the potential aircrew officers and airmen were documented, medically examined, X-rayed and generally prepared for the next move to an Initial Training Wing.

Although the Medical Branch were allowed twelve places on the flying courses, only two had been taken up at this time. The other fortunate doctor to be selected, whom I met for the first time at Regents Park, was Squadron Leader J. Park. A Scottish international rugby player and a physiologist, he had been working at the Institute of Aviation Medicine on the problem of air sickness, particularly in gliders. We found that our Initial Training Wing was at Torquay and in a few days we packed our kit and took a train for Devon. There, many of the large hotels had been requisitioned to house the thousands of cadets preparing to become aircrew. The officers also were in one of these hotels which looked out over the promenade to Torbay and, though shorn of its pre-war luxury, there still remained the lovely gardens, with borders of early spring flowers. The weather was perfect and the bright sunshine on the sparkling sea made it hard to remember the war, until perhaps a column of fast marching cadets went by, or a low flying formation of Spitfires roared overhead on their way to attack the enemy in France.

The officers were a mixed lot from every walk of life and from most Branches of the Air Force. The ex-operational navigators, air gunners and wireless operators were in the majority; quite a number of them wearing the D.F.C. or D.F.M. and with many hundreds of hours of active service flying behind them. The rest of us were from ground branches, accountant, equipment, and administrative officers, and now for the first time, medical officers. Also with us were a few army officers, seconded to the R.A.F. for pilot training, who on completion would probably find their way into Army Co-operation Squadrons.

I feel I must mention one officer by name. Even in those early days of initial training this tall fair-haired young air gunner impressed all of us with his enthusiasm and nerve. His presence and undeniable good looks were unspoilt by the slightest trace of conceit. At all times gay and full of humour one felt sure that here was one who would make a great pilot and a fine leader. His name was John Derry. He certainly fulfilled every expectation we had of him both in his career in the R.A.F. and later as a test pilot with De Havilland. He was indeed a 'natural' and aviation lost much when he crashed at the S.B.A.C. show at Farnborough in front of thousands to whom his name had become so well known.

The course was admirably arranged and our instruction in elementary ground subjects proceeded smoothly and with very little pain. We were taught the rudiments of navigation, meteorology and theory of flight. At other classes we battled with the elusive dots and dashes of morse and were introduced to the intricacies of the Browning Gun and its proclivity for having a stoppage. With the classes, parades and P.T. we were kept fairly busy though not so much that we were unable to sample the excellent amenities of Torquay. The apparent remoteness of the war, continued fine weather and the freedom from the responsibility of our previous jobs on wartime stations, seemed almost like a return to student days. The weeks went by and the time grew near for us to leave and proceed with the next step in the training; to attempt our first solo.

Some little time before our posting there occurred an incident, which while darkening the sunny atmosphere of the town must surely contain one of the most incredible escapes on record. One morning one of our number, a bulky American officer in the R.A.F., with the inevitable camera round his neck—and I record his size not out of fellow feeling but because of its pertinence to the story—was walking along the front by the sea in company with a sailor and a soldier. With the innate friendliness of the Americans he had engaged them in conversation. Suddenly, and too late, the siren wailed through the spring sunshine as a number of FW 190 German fighters swept along the promenade with cannon and machine guns blazing. The American officer, with a temerity evidenced by his D.F.C. and D.F.M., calmly photographed, head on, a 190 coming straight at him. The fighter swept over his head and unbelievably he was not hit. His companions, who had been walking either side of him, were lying on the ground, one decapitated and dead, the other disembowelled and dying. The officer must have had a girth at least as big as the two together, and yet although he was between them, he escaped. The reason, I imagine, must have something to do with cones of fire, distance and speed, but whatever the explanation of his escape, the developed film produced a perfect head-on picture of a FW 190 which could well have been used in a series for aircraft recognition.

At the start of the Commonwealth Training scheme aircrew cadets had gone straight from initial training to Canada or Rhodesia. But the failure rate had been high and it was decided that some means must be devised of discovering a pupil's ability to fly before incurring the expense of money and time spent on the long trip to the Dominions. The result was the Grading School at which cadets would receive twelve hours preliminary flying in Tiger Moths to ascertain which had the most aptitude. In the main it turned out that those to go solo quickest became the best pilots and failed less often at advanced stages. It did not imply lack of intelligence in the others, but a different level of physical ability, as it might in ball games and other sports. These still continued with flying training but as navigators or other crew members.

So we found ourselves at Brough Airfield near Hull for the first twelve hours flying of our course. We stayed a few weeks, during which Park achieved an immaculate first solo, and I a ragged conversion to the type, probably caused by the blase possession of a hundred hours flying time. All the members of our course passed without disgracing themselves and were sent on leave to await posting instructions which we hoped would mean Canada. The next stop was in an aircrew reception centre in Manchester. Here, Park and I being Squadron Leaders, were put in charge of a draft of fifteen officers and five hundred cadets, and told to await secret orders as to our port of embarkation. The endless rain, dreary quarters and perhaps a little of the usual homesickness, I am afraid, left most of us with rather a warped memory of Manchester as we waited to go to an unknown seaport to board an unnamed troopship.

The port turned out to be Gourock. From the quayside we peered through mist at a huge ship lying some way out, which by its shape, size and two funnels some expert recognised as the *Queen Elizabeth.* Both the Queens were then on trooping duties across the Atlantic and on account of their speed made the journey unescorted. We watched the disembarkation of American and Canadian troops, discovering later that no less than 26,000 men had been brought across on this trip. I was made security officer for the voyage, responsible to an officer on the permanent staff of the ship. At this time the *Queen Elizabeth* was an R.A.F. Command and all troops sailing in her came under the orders of the Air Force Commanding Officer and his staff. Our duties were to man the hundred odd guard posts throughout the ship to maintain order and control movements. Perhaps the most vital duty was the suppression of smoking on deck after dark, the slightest glimmer of light being visible in mid-Atlantic to a watchful enemy submarine. I heard later that on a previous trip a senior army officer who ignored a guard's request to extinguish his cigar was, when reported, placed immediately under close arrest, which is not too harsh a discipline to preserve the *Queen Elizabeth* and thousands of troops.

Maintaining a twenty-four hour watch, changing shifts and the general administration, proved no light task. The immensity of the ship and the tendency to get lost made the work all the harder. However, the trip was uneventful with fine weather all the way, and in three days from leaving Gourock we were approaching New York. Everyone had risen early to catch the first glimpse of the famous Manhattan skyline. It lived up to its reputation, appearing like a city in the clouds as the morning mist hid the feet of the towering skyscrapers. I think officers and men alike were excited at the thought of two or three days in New York before going north to Canada. But it did not quite work out that way. When we finally disembarked at one of the great piers we were hustled aboard the ferry to New Jersey and there entrained for Moncton in New Brunswick. Our disappointment can be imagined and the chagrin was not lessened when we learnt the reason for our bad luck. Apparently many of the cadets from previous drafts, finding the delights of the city irresistible after wartime Britain, had gone absent without leave, turning up at Moncton several weeks later. With no thought of desertion in their minds they reckoned that the extra time at play was well worth any punishment they might receive after. It was unfortunate that the authorities had tired of the game. So grumbling and helpless we were carried northwards through the beautiful country of the east coast into the maritime provinces of Canada and at last to the dispatch centre in Moncton.

After a week at the dispatch centre at Moncton, Park and I and several of the officers who had been with us at Torquay were posted to an elementary flying school at Neepawa, which we discovered in referring to the map to be about a hundred miles north-west of Winnipeg. Here in the heart of the mid-western prairies we at last started serious flying training. The aircraft we flew was the Canadian Tiger Moth which differed from the English version by having a canopy, brakes and a tail wheel. They were delightful little aircraft and the days passed swiftly and happily as we gained more confidence and skill. For the first time we were introduced to the link trainers and learned how to fly patterns on instruments and were taught the elements of bad weather flying while sitting safely on the ground. There was, of course, real instrument flying in the air under a hood which fitted under the canopy over the pupil. It was this part of the course that I remember best, because of my heavy handedness on the controls. Coming straight from the twin engined Anson I found difficulty at first in achieving the delicacy of touch required by a light aircraft. My instructor, who was also the flight commander, described my feet as a 'couple of ton weights on the rudder bar' and he usually expressed his opinion of my early efforts at instrument flying with a snort of disgust and a blasphemous expletive

After two months we took our exams and our final flying checks and, having not been found wanting, were pronounced fit to proceed to more advanced training. We had a short break which we spent on the edge of Clear Lake further north in the Riding Mountains. The lake was well named, for never before or since have I swum in such crystal water. Chalets and hotels bordered the water and the whole setting of mountains, log houses, pine trees and the gleaming lake itself, might have come straight out of one of the brochures in a travel agency window which one had gazed at wistfully but never thought would come true. Our next move was to the service flying training school just outside Calgary. We considered ourselves lucky in the posting to be near to a large city rather than out in the prairies. The aircraft we flew were Harvards, in every respect a service type of aeroplane as opposed to the elementary Tiger Moths we had just left. Powered by a Pratt and Witney engine it would cruise at 140 m.p.h. There was much more to be learnt about such aircraft with its flaps, retractable undercarriage, variable pitch propellers and radio. I think most aircrew will agree that this stage of flying training is the most exciting, when one feels that this is the real thing and it won't be long before the time comes to fly fully operational aircraft. As before, ground school alternated with flying periods but with both the exercises became more advanced. In the air, first the conversion to type, and then solo, circuits and bumps; later, cross countries, instrument flying, aerobatics and formation flying. Night flying came a little later, and the last part of the course before wings parade, was a move to the armament flight to learn air to air, and air to ground firing.

Like Graeme Anderson nearly thirty years before, Park and I found much of medical interest in its application to flying training. We both came to the conclusion, rightly or wrongly, that many of the younger men were kept on instructor duties too long. Their chief worry seemed to be their keenness to get on to operations. Instructors were usually selected from those who had done best on their own flying course and, following a period of learning how to instruct, were posted to one of the flying schools. It was quite natural that those responsible for training should wish to retain these above average pilots as long as possible, particularly as they became more experienced. They sometimes stayed as long as eighteen months or two years and the endless succession of pupils, good, bad, and indifferent who passed through their hands tended to make these instructors impatient and sometimes moody. We both felt that for the younger men, at all events, six months instructing would have been enough before proceeding on operations in bombers or fighters for which most of them had joined the Air Force.

Another most interesting trait we noticed in instructors, which occurred fairly frequently, was their dislike of teach-pupils instrument flying. It often occurred that an instructor, normally cheerful and patient with even the slowest pupil on all other exercises, would become irritable and even colourfully abusive, with a perspiring and sometimes 'ham handed' learner under the hood in the back of the aircraft. It is easy to understand how infuriating it must be to sit in an aircraft, flown by the pupil, which is slightly left wing low, skidding to the right and losing height for what must seem an interminable time before the errors are corrected. I had every sympathy for my instructors for it took some time to overcome the tendency to brood over one instrument while forgetting all the others. What would happen would be something like this: Sitting under the hood, perhaps a little tense, everything would go well for a while, then perhaps the aircraft would go slightly off course. When correcting this by the gyro one would forget about the turn and bank or climb and glide and a wing would drop or height would be lost. Although it appeared that these faults were corrected at once, in reality the time lag was considerable and caused by this broodiness over one particular instrument. The satisfying thing about flying on instruments is that though one may never become an ace in aerobatics and general polish one can by constant practice and application to the task become as good as the next man flying in cloud or bad weather. It adds much to confidence and stature when a glance at the instrument panel is enough to give a mental three dimensional picture of the exact position of your aircraft in space and its direction through the air.

About a month after starting at Calgary a case of airsickness occurred in our flight. It was unusual for this to happen at this stage of training as the chronically airsick pupil was usually taken off flying at an elementary flying school. It was brought to our notice both on account of this cadet's excellent progress and Park's work on the problem at the Institute of Aviation Medicine. After an interview with the boy and a discussion with the station medical officers, Park felt that it was not a case of true motion sickness and that other factors were involved. Having my wings already, I was allowed by the flight commander to take the cadet flying. We went through some of the usual exercises, steep turns, rolls, loops and spinning. He performed all these manœuvres in a polished and competent manner, appearing relaxed and confident. He did not complain at all, even when I repeated the exercises with, I must confess, a great deal less polish. Park and I eventually came to the conclusion, rightly as it happened, that the sickness was psychological and caused by a degree of temperamental conflict between the pupil and his instructor, though the lad had loyally mentioned nothing in his interview with the doctors.

The instructor was an excellent pilot, though a trifle morose and abrupt, and the incident was in no way a reflection on his abilities. We persuaded the flight commander to transfer the cadet to a more cheerful instructor with the happiest results, for the pupil not only passed out third in the whole course but gained his commission as well.

The weeks passed. Christmas came and went with an all too short five days in the Rocky Mountain resort of Banff Springs where some of us made our first shaky efforts to master the art of skiing. Whether five days was not long enough, or my particular centre of gravity is at fault, the skill eluded me. Indeed, I spent so much of the time on my back in the snow that I came to the conclusion that skis were a redundant piece of equipment for my method of proceeding down the nursery slopes. Back at Calgary we were increasingly busy studying for the approaching examination in ground subjects and practising the exercises of our final flying checks before being awarded our wings on the last parade of the course.

During the course we had become interested in the various methods used by instructors in teaching pupils to land a new type of aircraft. Curiosity was aroused by the fact that it seemed fairly common for most of us to have patches when we made bad landings, and by bad I don't mean unsafe, but not with the amount of precision that warrants an inward glow of pleasure on making a perfect three point landing. Whatever the reason for this anomaly it certainly was a fact and, if not dangerous, was irritating in the extreme. Park and I carried out a rough experiment based on an early suggestion made by Squadron Leader Davidson. He was a pre-war consultant in surgery and a member of the Auxiliary Air Force, who after a spell on instructing at flying schools in the early part of the war, gravitated to the staff of the Institute of Aviation Medicine. He had pointed out that at the right moment of an aircraft's glide approach when coming in to land there occurred an optical illusion which indicated when the pilot should round out that glide in order to make a perfect wheeler or three point landing. It is certain that the correct round out of an approach is the basis of all good landings; that is, those which bring the aircraft straight and level a few inches above the runway so that pulling the stick back will stall the aircraft gently on to the ground. I am of course referring to the techniques appropriate to the aircraft of that time.

Davidson described the illusion this way. He said that on the approach to land the airfield appeared quite flat until at a certain point in the descent the field became like a saucer or if landing on a runway the further part of it appeared as a slope upwards. When gently checking the descent the illusion disappeared and the field again became flat. If this flatness were maintained by continuous backward movement of the stick then the perfect roundout was achieved. We were convinced that Davidson was right because both of us used the method to counteract the patches of bad landings. The method was of particular interest as we had noticed throughout the course that there was a wide divergence in instructors' 'patter' in attempting to describe to pupils the height at which they should round out their glide. Such phrases as 'twice the height of double-decker bus' or 'half way up the control tower' were commonly used. We felt with Davidson that if such a visual sign, whatever the theoretical explanation, were constant, then the time taken to go solo might well be considerably reduced. We also photographed the runway with the cine camera gear from an approach in a Harvard. The resulting film showed a dip in the runway at the moment of checking the descent, but as might be expected on a film the effect was reversed and the slope was downhill. One other strange thing about this phenomenon was that it was rarely seen by very experienced pilots.

At last the great day arrived and all arrangements were completed for the wing's parade. It is a happy occasion, I think, for instructors and permanent staff as well as the pupils. Families and friends are allowed to attend to watch the proud moment in a cadet's life when he is awarded his wings on behalf of the Monarch, by an air officer of high rank. I was excused the parade by the commanding officer since there was no reason for the pilot's badge to be given twice. Park was therefore the senior pupil on parade; he not only passed out head of the course but had taken the highest marks ever attained in ground subjects and flying. As I watched I felt very proud of the honour he had brought to himself and the medical branch.

Park and I were not to proceed straight away to the dispatch centre at Moncton through which we had passed more than six months before. About a month before the wing's parade we were surprised to receive a cable from Yale University. It was from Professor John Fulton, the eminent physiologist, inviting us to visit and stay with him at his home in Newhaven. In reply to a signal to the Director General of Medical Services, asking for permission to accept the invitation, we received also authority to visit other research centres in the United States; the programme to take a month. This was indeed good fortune and exceeded our highest hopes. We set off by train from Calgary, to cross the continent to Toronto. The journey took two and a half days and although full of interest it was a relief to leave the train on our arrival. We stayed a week in Toronto at the Clinical Investigation Unit which was similar to the Institute of Aviation Medicine at home. The Canadians were kindness itself and spared no pains in bringing us up to date on recent research and development. From Toronto we went south again by train, through New York to Washington, so once again we had no chance to prove the city; in fact I think in all we went there five times and as it happened never succeeded in seeing any more than the station. In Washington we visited the Medical Headquarters in the vast Pentagon and the Naval Research Centre at Bethesda. Our next visit was to the Aero Medical Unit at Wright Field in Ohio where amongst other things we had a ride on the man carrying centrifuge. I remember only too clearly the nausea and giddiness caused by the rather sudden deceleration. It was here too, that we met Colonel Lovelace of whose flying and parachute exploits we had heard so much in the past.

From Wright Field via Washington we travelled south again leaving behind the winter cold of the northern states. The weather became warmer, the foliage more exotic as we passed through the southern states to the great naval air station at Pensacola in Florida. This surely must be one of the most magnificent of service units in the world. There are no less than seven airfields in a half circle surrounding the central control tower and on the seaward side toward the Gulf of Mexico the sheltered bay with the seaplanes and flying boats at their moorings. All over the huge station with its barracks, married quarters, golf course, and playing fields, azaleas were ablaze against the dark background of massive trees festooned with grey spanish moss so characteristic of the south. Not only were American service men receiving flying training, there were many courses of British cadets. We were slightly envious of their luck in learning to fly in such idyllic surroundings. As at the other research centres, we were introduced to the latest developments and thought in aviation medicine.

Our time was running short so we moved on along the coast to New Orleans where we were to change for San Antonio in Texas. There were only five short hours between trains, and after seeing as much as we could of this delightful city, we remembered Frances Parkinson Keyes' famous book and profitably employed our last two hours having 'Dinner at Antoines.'

After a seemingly endless journey through the huge state of Texas we arrived at San Antonio and from there visited the Flight Surgeons' School at Randolph Field. Here doctors were trained in aircrew selection and aviation medicine and, on passing out as aircrew examiners, were posted to squadrons for flying experience. Though not trained as pilots they received, after a certain number of hours, a special pair of flight surgeon's wings to denote their speciality in aviation medicine and the care of aircrew.

Flying north to Washington with our tour nearly at an end, we were met at nine o'clock on a wet cold night at Newhaven Station by Professor John Fulton himself. We had dined on the train and arriving at his lovely house we soon settled down to talk in his study lined with rare books. This gracious doctor, of international repute in the world of physiology, made us feel very much at home. Under the influence of his inspiring conversation, it was after midnight that we rose to retire. But before doing so we were taken to the attic to see the table on which Lewis Carroll had written Alice in Wonderland. Dr. Fulton, a noted anglophile, had brought the table from Oxford where as a don he had lived for some years in the author's old house.

The next day was spent at the University where we were introduced to members of the physiological department and visited the magnificent Harvey Cushing library, of which Dr. Fulton is so justifiably proud. After lunch, to our surprise and certainly to my dismay, we were asked to address a sizeable audience of members of the physiological staff. Park talked well on the medical problems of flying training, and I stumbled through some suggestions for useful research in aviation medicine for the following year. The interest of Professor Fulton and his associates did much to relieve my anxiety of appearing impertinent in addressing so many experts on their own subject.

Back at the Doctor's house we found that a small dinner party had been arranged for us to meet socially some members of his staff and their ladies. We were to catch a train at ten that evening. Dr. Fulton again took us in his own car and saw us safely on to the train for Moncton. It had been a memorable twenty four hours to end an exciting tour full of so much of interest to both of us. Travelling north through the night we felt that had we both been professors of physiology or air marshals we could not have received more kindness or interest in our work.

Back to Moncton and thence to Halifax, there to board—in complete contrast to the *Queen Elizabeth*—a five thousand ton banana boat. There were compensations for lack of size however, as the S.S. *Ariguani* was still a passenger ship and, unlike the troopships on the Atlantic run, there were four meals a day and a well stocked bar. The trip over was also in contrast to our first crossing. Instead of three days the journey took seventeen; on three of which we were reduced to a speed of one knot in the face of a seventy mile an hour gale. The little *Ariguani* built by the craftsmen of the Clyde rode out the great waves with the daintiness and certainty of a yacht.

Standing one day with the captain on the bridge during the storm we were watching the lumbering motion of the Liberty ships nearest to us in the hundred strong convoy. He told me that on several occasions he had seen them break in two in gales no worse than we were fighting. At last the wind lessened and once again we moved eastward at the usual ten knots of the convoy. Approaching the west coast of Scotland the convoy split into two; one half going south, we presumed to Liverpool. The rest of us were to round the north of Scotland and eventually tie up in a small port on the north shore of the Firth of Forth. The gale had blown itself out and the weather was fine. That night we anchored in one of the beautiful lochs on that coast. We shall never forget that scene. The orange light of the evening sun etched the mountains and hills on the darkening sky as the ships steamed slowly in line astern up the loch. Suddenly, from the forecastle deck of the ship behind us, the thin skirl of the pipes called us 'over the sea to Skye.' I glanced up at the bridge, at the motionless figure of Captain Wallace. Recalled from retirement at the beginning of the war, he had spent four years in the Atlantic convoys. Another trip completed, another cargo safely carried. The anchor chain ran out, the engines were still; and we were home.

By 1944 the Commonwealth Training Scheme had been so successful that there was often a wait of some months before completing the whole course at an operational training unit. Park and I returned to the Medical Branch for three months and were then posted to an advanced flying school for a refresher and preparation for fighter operational training unit. The A.F.S. was at Ternhill and we flew Master II's with much less pleasure than the Harvards in Canada.

They were much trickier to fly and were supposed to be a good preparation for Spitfires which, when we finally flew them, appeared to us to be much more akin to Harvards, though of course twice as fast. We moved from Ternhill to Kirton-in-Lindsey in Lincolnshire in the October of 1944, for the last lap of our training.

First, we had the conversion to Spitfire V's at the satellite aerodrome to which we had to cycle every morning. The weather was bitterly cold and I well remember while pedalling through those cold Lincolnshire lanes, being passed with monontonous regularity every day by a nice warm well-lighted bus carrying Italian prisoners of war to their work on the surrounding farms. After being instructed on the cockpit layout, fuel system and general handling of the Spitfires we were shown the correct circuit and approach in a dual Master. Dual instruction was of course not possible on the single seat fighter. The weather was bad for three days after our initial lesson and so none of us were able to tackle the Spitfire. The fourth morning, though the weather did not seem better to me, the flight commander curtly informed me that I could go solo and that he preferred the aircraft back in one piece. I mention his severity as an example of the atmosphere of this course, which was completely different to that of the previous schools. Here we were but a few months off a posting to a fighter squadron, where only the best was acceptable and anything less might lead to the failure of a mission. Throughout the whole course we were never allowed to forget that life was earnest and the highest standard was expected of us. The keenness and skill of the instructors, all with operational fighter experience behind them, kept morale at its highest level, and caused us to strain every nerve to live up to the traditions of a fighter pilot.

But to go back to my first solo in a Spitfire. As I carried my parachute out to the aircraft allotted to me, I repeated the cockpit check to myself in an effort to ignore a tendency to hollowness in my middle regions. At the aircraft a flight sergeant was waiting with a battery trolley already plugged in. He gave me an encouraging smile which helped not a little. Parachute on and into the aircraft; safety belt fastened; oxygen and radio checked; undercarriage trim mixture; pitch and so on; all through the well known list of things to remember before taking off. I primed the engine and signalling to the flight sergeant, pressed the starter button. The engine roared into life and after the trolley had been disconnected, and the chocks dragged away I started taxying down the perimeter track to the runway in use, swinging the aircraft from side to side to see round the great nacelle enclosing the engine.

The engine stopped. Hastily scanning the cockpit and instruments my eye became fixed on the petrol cock which sat smugly at the 'off' position. Viewing with dismay the prospect of climbing out and returning to the Flight to admit my blunder, I caught out of the corner of my eye the flight sergeant and an airman dragging the starter trolley.

'Flight, I'm terribly sorry, but . . . .'

'That's all right sir, 'tisn't the first time it's happened—have you turned it on now? Good—Switches off—we'll have another bash.'

A chastened budding fighter pilot taxied to the runway with mixed thoughts but basically wishing that a certain flight sergeant could be promoted. Turning into the wind after receiving permission to take off I opened the throttle and experienced for the first time a really good push in the back as the Spitfire gained speed and left the ground. It was very bumpy in the thundery weather and it was some considerable way on to Lincoln before I had sorted myself out, throttled back to correct revs and boost and was able to take a little notice. It did not take long to realise what a perfect aircraft the 'Spit' was and what a delight to fly. For the next few weeks we practised formation flying, aerobatics and generally learnt to fly the aircraft, before going on to the real business of learning how to fight as well as fly.

From this we moved back to the main airfield at Kirton where we were posted to one of the flights. Our instructor was a tall Norwegian who for the rest of the course struggled to teach us all he knew of fighting in the air. Battle formation, ground attack, low level flying and dogfights; he took us through all of them. He worked us hard and his severity during the day was a complete contrast to his friendliness and charm in the mess in the evenings. The weeks slipped by and the time came for our final check, a dogfight with the flight commander. He was a young American officer in the R.A.F. with two tours and many destroyed enemy aircraft to his credit. I must confess that I felt my age, trying to outclimb and outwit so experienced a pilot, but it was worth everything when back on the ground to hear his laconic 'good enough' and know that one had a high enough standard for posting to a squadron.

I think we both regretted a little that we were not to have squadron experience although we were naturally keen to be posted to a job of aviation medicine in one of the commands. It had been a wonderful ten weeks, and one must confess that the spirit of the station had imbued a strong desire to have a go at the real thing, though perhaps this is not one of the attributes which should form part of the make-up of a doctor.

5

Doctors in the Air

I HAVE considered in chapters of their own, major problems such as oxygen supply and the stresses of 'G.' There were however many others which occupied members of the staff at Farnborough and the flying doctors in the commands. It was perhaps in Bomber and Coastal Commands that doctors and physiologists flew most when investigating such diverse problems as night vision, searchlight dazzle, air sickness and the applied psychology of navigation and instrument flying. When the Germans failed in the Battle of Britain to subdue the country by daylight bombing, they increased their night bomber force. Our defence of anti-aircraft guns was strengthened by the expansion of the night fighter force. At the same time our own bomber force was enlarging and pressing further into the enemy occupied territories and Germany itself. As this bombing and night fighting intensified the range of research and development widened. Pilots had to be specially selected for their powers of night vision. Crews had to be taught correct methods of searching in the night skies. Gunners must see the enemy fighter first, and pilots of our night fighters had to prevent the arrival of the enemy bombers over the target. Methods were devised to prevent the glare of searchlights blinding the vision of the crew at night. Schools were started to train aircrew in night vision, and research was carried out in the laboratories into the value of vitamins in improving sight in the dark. These visual problems were many and varied but the early work of doctors and psychologists at Farnborough, Central Medical Establishment, and at Cambridge University, was concerned with the adaptation of the eyes to seeing at night, and methods of reducing glare from the illumination of instruments on the blind flying panel. They discovered that aircrews' night vision was markedly improved by wearing dark goggles for a half to threequarters of an hour while sitting in the crew room at readiness. The period before take-off, after the bustle of briefing, was never very pleasant at the best of times, and to immure the unfortunate aircrew behind dark glass, unable to read or move about was not really acceptable. Luckily it was also discovered that adaptation was very little less effective under red lighting which was sufficiently good to be used in place of almost complete darkness. Goggles with ruby red lenses were developed and they allowed the wearer to read and move about while his eyes were becoming adapted. At the same time improvements were made in instrument lighting systems that ensured that the amount of illumination could never be such that night adaptation could be upset. The crews were encouraged and trained to use their lights intelligently and at all times to guard against the effect on their companions of the careless flash of an unshielded torch or the misuse of their cockpit lighting. Attention was paid to the instrument panels themselves and suggestions were made to the technical people concerned, for more simple markings on the dials for night and day use.

Even in this sphere of night vision, oxygen and its ever present problems was involved. It was soon established, in work in the field and laboratory, that oxygen lack affected sight at night more than by day. It was discovered that oxygen materially increased the range of vision at night if it was breathed from 4,000 feet upwards. It eventually became the practice for crews to use oxygen from the ground up to their prescribed altitude. This measure increased the vision of an air gunner to such an extent that at 16,000 feet his vision was as much as forty per cent improved or so that he was able to spot an enemy night fighter nearly twice the distance away than he could without oxygen.

Many other tests were carried out on conditions that might affect the ability to see at night. Particular attention was paid to those drugs that aircrew might use to ward off fatigue or illness. For example alcohol, benzedrine and caffeine against fatigue, hyoscine for air sickness, and mepacrine and quinine for malaria, were all investigated for their effect on night vision. None of them was found to be harmful if not taken to excess and if administered in their correct doses. Excessive smoking however was found to lessen a man's ability to see well at night.

The satisfactory camouflage of bombers at night was another preoccupation of the workers in the field of visual and allied problems. It was thought at first that the matt black surface of the aircraft would reflect the least light from the piercing beams of the enemy searchlights. But in practice this was found to be an incorrect assumption. As well as searchlights, marker flares and fires on the ground lighted up the whole target area. Clouds on an overcast night and those formed from the smoke of the intense fires raging below formed a brilliantly illuminated back-cloth against which the large black bombers were clearly silhouetted and were an easy prey to the enemy night fighters and ground defences.

New methods were being tried constantly to offset the danger of dazzle on the crews' vision. Gun turrets were screened and slotted goggles and smoke screens used to protect the men's eyes against the glare from searchlights and the flash of tracer bullets. Dirt and scratches on perspex transparencies were shown to reduce visibility An ingenious apparatus was devised at Farnborough to measure the scatter of light and resulting visual loss that could be caused by dirty and scratched perspex. This instrument was of more than scientific interest for as a bonus it did much to convince aircrew that care of transparencies might well be a life saving measure rather than a fussy routine.

Good vision at night was considered so important that in 1942 an experimental night vision training centre was set up at Felixstowe by the consultant in ophthalmology in conjunction with the Operational Research section of Coastal

Command. Air Commodore P. C. Livingston, who later as Sir Philip Livingston became Director General of Medical Services, was foremost in the field of vision research. He was also a pilot and much of his flying was directed towards the solution of the current problems. His was the invention that first produced the test of night vision by which pilots were selected for night fighter duties. In close association with Sir Philip in this work were K. J. W. Craik and Squadron Leader E. A. C. Goldie who devised the perspex apparatus I have just described. Soon after the establishment of the centre at Felixstowe, Bomber and Fighter Commands formed night vision schools of their own. These were primarily to train aircrew who, having finished an operational tour, were to be posted to training units as air gunnery and bomb aiming instructors. There they could pass on their knowledge and organise courses for pupil aircrew being prepared for operational squadrons. This move proved to be a success and Night Vision Training Schools were established throughout all the operational commands. At these centres the emphasis was on encouraging aircrew to make the best use of their eyes. To this end various synthetic systems were developed which could simulate conditions of bomb aiming and gun firing, and practice could be obtained in a dim light similar to an aircraft cockpit. Ball games played in reduced light were found to be particularly valuable in training the eyes of aircrew to recognise the path of a fast moving object at night. As an adjunct to these methods exercises were carried out at night in the field.

Another of the early problems to be investigated was airsickness. This became the project of a Flight Lieutenant who was posted to Farnborough after the fall of France. While on the continent he had started flying, and after a while at the 'Lab' he obtained sufficient hours to qualify for his wings. He had a distinguished career in aviation medicine and his persistence in going into the air to resolve a variety of problems resulted in his receiving both the Distinguished Flying Cross and the Air Force Cross. His medical interests were catholic and in his flying his work ranged from the testing of prototype equipment on operations, to the evaluation of work loads and strains on different crew members. As an example he might spend his time during a sortie evaluating the amount of work involved in climbing in and out of a mid-upper gun turret and estimating from that the amount of oxygen necessary for the task. As well as his early flying with Coastal Command and, towards the end of the war, many trips in Beaufighters and other aircraft in the Far East, he achieved the remarkable number of ninety-eight sorties with Bomber Command crews. His taste in flying became as catholic as his research work, for in addition to becoming an experienced parachutist he made numerous flights in gliders while pursuing his investigation into airsickness. It was through his work on this problem that I met Winfield in the early days of the war. He chose Coastal Command aircraft at the start of this work as at that time they flew longer sorties than the other commands, often through the turbulence of the North Atlantic weather fronts. In due course he came to Pembroke Dock, a Sunderland Flying Boat base near Milford Haven. I was then the senior medical officer on this station and I well remember his visit, though I saw very little of him in the week that he stayed with us. He so arranged his flying programme that he seemed never to be out of the air. It is certain that he logged over a hundred flying hours out of the hundred and sixty eight he was at Pembroke Dock. The conditions for his investigation were apparently ideal, for the Sunderlands and Catalinas were regularly making sorties of twelve to fourteen hours duration, more often than not through rough and turbulent weather. Looking back over the years I am reminded that the incidence of airsickness was low on the station. Apart from the rare occasions when the weather was so rough that even experienced and hardened crews were sick, just as regular sailors can be, I can only remember one case which was incapacitating for any length of time. To my shame I must confess that the patient was the medical officer himself. It was on my first trip on a Sunderland after a total flying experience of half an hour on a Magister. It lasted for fourteen hours and we flew through three storms at 1,500 feet above the sea. I think it was the combination of three factors which eventually brought me low. I might have managed to avoid being sick but for the cold, the evil smelling pipe which the captain smoked continuously, and finally the lunch. The Sunderland is a civilised aircraft, equipped with wardroom and galley in which one or other member of the crew cooked the main meal. The menu, imprinted for ever on my memory, consisted of fried pork chops and chip potatoes, followed by generous helpings of tinned fruit and condensed milk. It was fortunate for me that the Sunderland is equipped with an efficient water closet, for I spent the rest of the flight lurching between there and the bunk in the wardroom.

It was these fairly substantial cooked meals in the air that Winfield criticised most strongly. He felt that they must predispose towards airsickness and advocated a lighter diet, emphasising particularly the value of dried fruit and nuts. But I think it is likely that Winfield, preoccupied as he was with the problem on all types of aircraft, thought that the incidence was higher than was actually the case. For the most part the crews were regular and experienced personnel and were thoroughly accustomed, indeed attached to the 'fry-ups' they prepared from the bulk rations provided. Certainly Winfield's recommendations were nowhere near as popular as he himself had been with his crew members and I am afraid the fruit and nuts lost out to the steaks and chops.

Squadron Leader Goldie was another member of the staff at Farnborough who flew regularly with the crews of Bomber Command. As well as his work on night vision he made some major contributions to the investigation on breathing rates and oxygen supplies. He developed a useful apparatus which determined the amount of oxygen in the blood and thus the degree of anoxia which existed if the system under review was in any way deficient. The advantage of this anoxia meter, as it was named, was that it made unnecessary the puncture of an artery to obtain oxygenated blood. This device, simple to use, was clipped on to the lobe of the ear and supported by a head band. Readings of blood oxygen amounts could be taken at any given moment, or for as long as they might be required. Goldie also set up a method of measuring breathing rates of aircrew when flying on operations. It was arranged to work from the economiser system, but in such a way that the crew member concerned was unaware that his breathing rate was being measured. The strain over the target area caused a faster rate with in its turn an increased consumption of oxygen. It was important that this figure should be known, so that the system should contain adequate oxygen for all contingencies. A colleague and friend of Goldies has described him to me as an intense scientist who was completely absorbed in his work at all times to the point of absentmindedness. He recalls Goldie arriving at the 'Lab' one morning conventionally garbed in uniform, but wearing instead of the usual sombre black, a tie of many gay colours. This dedication to the job in hand rendered him completely imperturbable and oblivious to danger. On one flight in a Lancaster over Germany, Goldie had gone along to take more recordings of breathing rates. He was noticed in the middle general of an unusually strongly opposed bombing attack to be quite unconcerned. He had set up his apparatus and sitting on the floor, without even a safety belt, was calmly taking readings of the pilot's breathing rate. The pattern of increasing rate when they crossed the enemy coast, building up to the panting of exertion and strain as they attacked, became a familiar experience to Goldie on the many sorties he made with the bomber crews.

The example and precedent set by Group Captain Corner led, sometime after his death, to the appointment of medical officers, qualified as pilots to all the flying commands, at home and overseas. The Flying Personnel Medical Officers on the staff of the Principal Medical Officer, were in addition, advisers to their Commanders-in-Chief on all matters to do with care of aircrew and aviation medicine. The position at Fighter Command was filled by a young Wing

Commander who had been on the original pre-war staff of the 'Lab' in 1939. He had followed his work at Farnborough by a period of aviation medicine in the U.S.A. and Canada. With this background and his skill as a pilot, he maintained the Corner tradition by flying regularly with the Spitfire and Hurricane Squadrons. Middle and Far East, Coastal and Flying Training Commands similarly appointed medical officer pilots to carry out the F.P.M.O. duties appropriate to the type of operations. Wing Commander Huins, in peace-time a general practitioner, took over the job at Bomber Command. He spent a tremendous amount of his time in the air, for apart from any other aspects of aviation medicine, he believed whole-heartedly in the good effect on morale of doctors flying with the crews on operations. He was awarded the A.F.C. and later a bar for his services in the air.

In bomber operations probably no group was more important than No. 8 commanded by Air Vice Marshal Donald Bennett. He had built up the Pathfinder force of squadrons as a spearhead of the attacks in Germany and the occupied territories. The task was to pinpoint the target and mark it for the main force to attack. This work presented special problems in aviation medicine, for success depended on the highest quality of night vision and navigation. It was however, not only Huins from Command and Winfield, Goldie and others from 'Lab' who flew to assess the problems that arose as the attacking force grew stronger and flew higher at greater range. Rather unexpectedly the senior medical officer of No. 8 Group played an important role in investigating the problems peculiar to the Pathfinders. Perhaps, unexpectedly is the wrong word, but usually Group medical officers were not pilots and were more than fully employed with the medical care and administration of the stations in the Group. Wing Commander John McGown was a pre-war member of the R.A.F. Volunteer Reserve. As a pilot, with a particular flair for navigation, he succeeded in finding time from his routine duties to fly regularly with the operational crews. He remains for all who knew and served with him an unforgettable personality. A distinguished figure, already over forty years of age and with grey hair, he stood out in the briefing and crew rooms of the squadrons with whom he flew. The applied psychology of Pathfinder navigation and night vision requirements were his special study. He made regular sorties in the Mosquitoes and Lancasters of the Pathfinder force using his skill as a navigator and on return reporting his findings to promote further research. He was at the same time able to experience the difficulties of glare and dazzle which I have mentioned previously as concerning the workers of the Vision Committee. The record of the number of sorties he made and the value of the recommendations that arose from his flying experience is indeed remarkable. I think it would be fair to say that many a youngster facing his first trip must have been heartened and encouraged by the presence of John McGown. I am sure that his chief reward was the respect and affection of his crew members who shared with him the experience of those hazardous and difficult flights. Dr. McGown was awarded the D.F.C. and the Pathfinder Badge.

Of the greatest importance as the men on the spot, were the station and squadron medical officers, for with the best will in the world, it was impossible for F.P.M.O's. at Command Headquarters to visit every station and squadron regularly. In their care of aircrew the station doctors dealt not only with aviation medicine but the organisation of ambulance services and rescue from crashed aircraft. Despite all their various other duties the doctors out on the stations at home and abroad must make the pilots and their crews the first consideration. While maintaining the highest standards of curative and preventive medicine, the doctor in the Air Force has that extra concern for those under his care who operate the aircraft. To be familiar with the type of aircraft and its role, understand the oxygen system and advise on the correct flying clothing to be worn is quite an added burden to the routine medical work.

But it is a worthwhile labour for the results pay handsome dividends, not the least of which is the confidence and, indeed, often gratitude of station and squadron commanders. This is particularly important if the doctor takes the work to its logical conclusion and spends every available minute with the aircrew, in the air, in the crew room and socially. For it is only by knowing men in all the spheres of work and play that good advice can be given to those in command.

It is not the slightest use waiting in the surgery for an overstrained pilot to report sick, for by then the damage is done, and a man who could have been returned to flying by judicious help in the early stages might have become a confirmed psychiatric case. It is by knowing the crews and their background, waiting for their return from an operation and if possible, as so many medical officers did, flying with them on their raids, that a doctor can best advise on a short rest or a spot of leave.

For example, a crew might have had a succession of near escapes, and the captain with his added responsibility become unusually quiet and reserved and almost imperceptibly solitary in the mess. These very early indications will probably not be noticed by the otherwise preoccupied members of his squadron and certainly not by a medical officer whose only thought is routine medical duties. But to a doctor who has troubled to learn about the care of aircrew the position should be quite clear, and in nearly every case a word to the squadron commander would result in a quick 48 hour pass on which the pilot and his crew could get into other kinds of trouble than flying through weather, flak and enemy fighters. It is perhaps a pity there is no clinical record of the beneficial and restorative effects of those 'forty-eights' in the 'Big City' on those who temporarily have had enough.

At a station in the North in 1942 there occurred a crash one night that instances the value of an interest in flying of a station medical officer. The aircraft was a Hudson bomber with a Rhodesian crew of four. On crashing the aircraft burnt fiercely. All the crew were rescued from the wreck. The captain and navigator were severely burnt, the wireless operator was killed and, strangely, the co-pilot was uninjured.

It is this sergeant pilot who claims our interest. About three weeks after the crash the phone rang in the station medical officer's office. The call was from the sergeant pilot's flight commander. 'Would the doctor see this N.C.O., as, since the crash in which his friends had died and been so badly hurt, he had lost his confidence and the question arose of taking him off flying. He now had no crew and was being checked out to be a captain himself, but was so shaky that even his circuits and landings were hopeless.' The medical officer would see him right away.

From the interview it emerged that he had gone happily back to flying, indeed glad to be occupied enough not to brood over the loss of his friends. But, whereas before the crash he had been an above average pilot, he flying since had been 'plain ropey.' He was tense and sweating and had the greatest difficulty in even landing safely. He was genuinely keen to get on to operations and was obviously depressed at what he thought was an inexcusable weakness.

The doctor was one of those few who had managed during war time to get his wings and I gathered from his story was bursting with over-confidence in his flying skill, so often occasioned by gross inexperience. He in his turn rang the flight commander and requested the loan of a Hudson. The reply was short and to the point. It may be all right for the 'Doc' to flog a 'clapped out' Anson around the sky but a Hudson was a very different thing. The Doctor pointed out with dignity that he was only to be an observer of clinical symptoms and the sergeant, a qualified Hudson pilot, would be in full control. Eventually, but with some trepidation, the flight commander agreed.

That afternoon as they waited at the end of the runway, the doctor's assurance began to wilt slightly. The history had not been exaggerated. White and tense, the pilot waited for permission to take off. The following few minutes were full of interest to an impartial observer. The doctor recalls that even in his ignorance and inexperience the performance

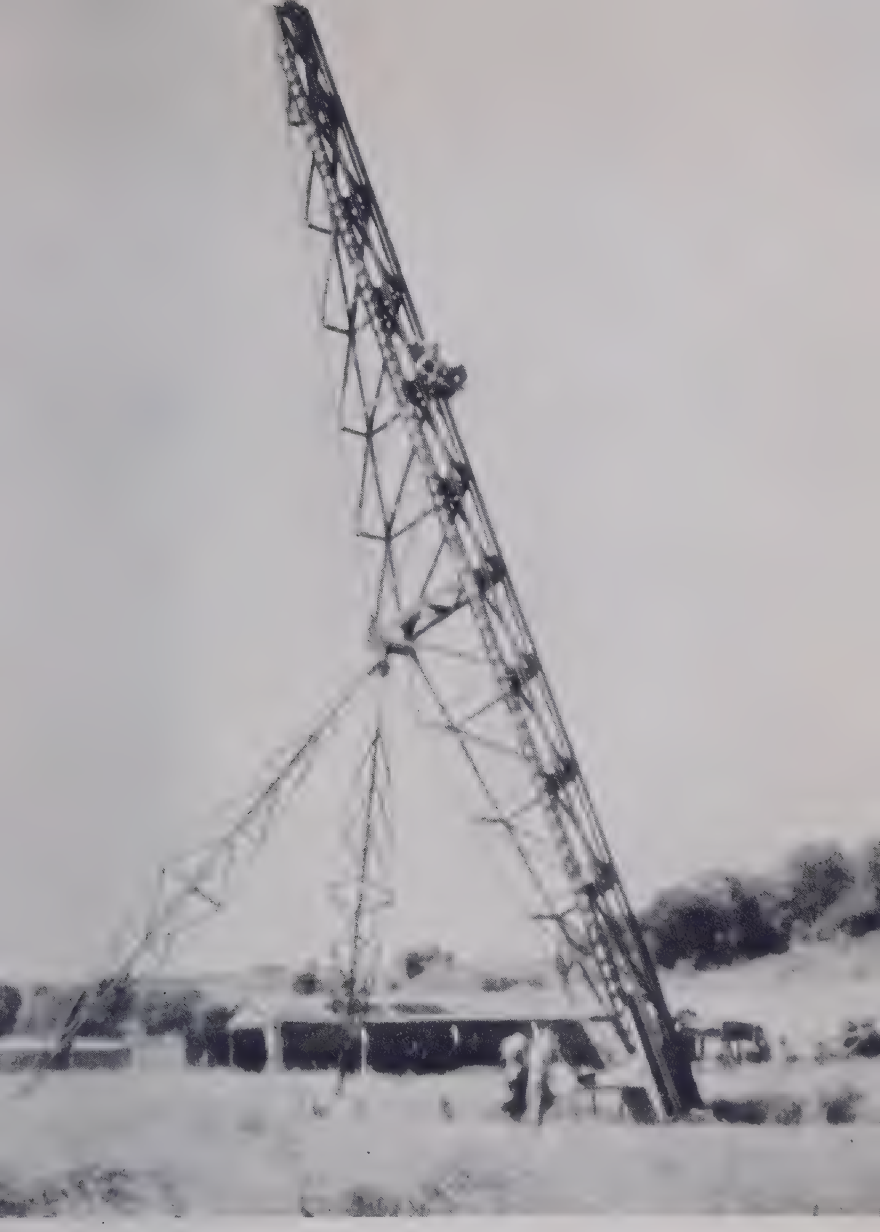


PLATE 8

A ride on an ejection seat testing rig. This was used to find the best type of cushioning through which to transmit the shock. (At one time the rig was vertical, which gave the test subject an unpleasant feeling of hanging over a precipice).

PLATE 9
Above—A more advanced stage of the work: live ejection from a Meteor Mark 7.
Below—Free fall parachute jump.

of take off, circuit and landing left a lot to be desired. On touching down they left the ground again for twenty feet and 'kangarooed' down the runway, eventually halting only a very few yards from the hedge. Every action of the pilot from the time of take off, had been that of a man under tension. The sergeant turned to his passenger. It was no use, it had been as bad as that ever since the crash. He had tried desperately to get a grip on himself. The doctor blandly replied that after all they were down in one piece, and added (with no small measure of truth at that time) that the sergeant's landing was on a par with his own method of arrival on the ground. 'Try again.' The pilot brightened a little and taxied round for another take off.

They sweated it out together, and after an hour and a half the doctor found himself being flown by a competent and relaxed pilot. Returning to the sick quarters for a cup of tea the medical officer asked the sergeant to come and see him at any time with any problem. The pilot never returned to the surgery, but many years later, the war over, the doctor was visiting the Air Force Headquarters in Rhodesia. Walking down a corridor he was stopped by a young flight lieutenant. 'Do you remember me, Sir?' 'Your face, yes—but when and where?' 'On Hudsons in '42—I was a sergeant pilot then.' 'Yes—of course—how are you?'

And so on to the usual reminiscences. But the real pleasure in the meeting, for the doctor, was to notice that his erstwhile patient was wearing the D.F.C. and Bar.

One of the most important tasks of the medical officer on a flying station is the perfection of the crash drill used in the event of accidents. Good liaison with flying control is essential and some system of immediate contact with the sick quarters, either by direct line telephone or alarm bell, is needed. There are many other factors involved if the ambulance is to arrive at the right spot when the crash is off the airfield. Orderlies and drivers must be familiar with the surrounding countryside and maps of this and the aerodrome itself, are usually placed in flying control, sick quarters and the ambulances. These maps are ruled off in conveniently sized and numbered sections, whose reference can be given in the orders to the ambulance and crash crews.

In the R.A.F. when flying is in progress there is always a doctor on duty who goes immediately to the scene of an accident. Station commanders and flying personnel have always insisted on the doctor being available at once, though on most occasions there is little that can be done at the site of the crash except simple first aid, and the injured are usually rushed to the sick quarters where there are all the necessary facilities. Apart from the morale effect and comfort of having a doctor's attention, rather than a first-aider, when one has been smashed up, I believe there is a more important reason for the medical officer to be the spearhead of the rescue teams.

It was brought to my notice very forcibly at the beginning of the war by an extremely irate and experienced flying boat captain. Almost my first job as junior medical officer at Pembroke Dock in South Wales was the recovery, from the shores of the Haven and from the water itself, of the bodies of a Sunderland crew of nine members who had crashed about three weeks before. The bodies were reported found, one or two daily, over a period of about ten days. I was glad that I had not known any of the men for they were not a pretty sight. The waves and rocks and voracious attention of many sea creatures can play havoc with a defenceless body and make recognition a difficult task.

In my ignorance of flying and its strains and finding the identification increasingly uncertain as the days went by, I made my big mistake. Without thought, and foolishly, I asked a young pilot officer to accompany me on one of the recovery trips in the Air Sea Rescue launch. He had been friendly with all the missing crew and willingly agreed to help. The body we pulled aboard was more than usually battered. The face was almost gone and only shreds of clothing remained. I was too absorbed in seeking indentification marks and wrapping the poor maimed body in blankets to notice what effect the sight of one of his former friends had had on the pilot. At all events he rather naturally failed to recognise the corpse.

When we got back to the jetty, the flight lieutenant who was the young man's captain, was waiting for us. As I stepped off the boat he took me on one side. For the next five minutes I was told in no uncertain terms and with a generous admixture of seafaring adjectives what a 'clot' I was. His main point was that no matter how hardened and experienced a flier is, he should if possible, never see unnecessarily, the sort of scene that I had so misguidedly exposed to his young second pilot. The flying boat captain who had come from the merchant navy into the R.A.F. was at the time one of the most senior of flying boat pilots, he was also one of the bravest men I have met. He finished by telling me that he had dragged a dead pilot from a burning wreck some time before and that the image of the charred face remained with him for many weeks to come. I learnt a very sharp lesson.

Bitterly ashamed, and obviously looking it, I turned away. He was, of course, dead right and I have believed ever since that it should be one of our main objects to perfect the crash arrangements so that we, the doctors, are always there first and have dealt with the situation no matter how macabre. My depression was relieved later that evening when he came up to me with a friendly smile and a spare pint in his hand and said, 'What about coming flying with me sometime Doc?' So I learned more than just that one lesson from him and a few weeks later actually managed, under his watchful eye, to get a Sunderland off the water and down again in one piece without any help.

The prompt attendance at aircraft crashes involves not only the meticulous organisation I have mentioned but sometimes a considerable amount of danger. On many occasions the aircraft is on fire, itself a big enough hazard to the crash and ambulance crews, and as well there is the risk of fuel tanks, ammunition and bombs exploding. I remember one night in 1942 a twin-engined bomber crashed into a wood near the airfield. The duty orderly and I in the ambulance reached the spot in less than five minutes, maintaining our proud record of always beating the fire tender. The aircraft was ablaze and ammunition was exploding at intervals. I shall never forget that orderly. He could not have been more than five feet tall. Leaping in and out amongst the flames and against the background of leafless trees he looked a veritable sprite from a Grimm fairy tale. The danger was small, though he was not to know that, for with the extensive damage to the fuselage the four members of the crew were fairly easily dragged from the edge of the main fire. They were all dead.

While the fire tender was dealing with the flames and we were recovering our breath, I suddenly realised that I had not seen the ambulance driver. It seemed on enquiry that he had told the wee orderly that he would rather not come and would stay by the ambulance which he had to leave some hundred yards away. Thinking of the enormous courage of that little man, as I ran back to the ambulance, roused a fury that brought me as near to offering physical violence to an airman as is wise if you don't want to be court martialled. That driver was about a foot taller and twice as heavy as the little orderly and yet he had skulked outside the wood when his help and strength might have been vital. I recall this incident not because of its actual danger but because it is one more of the oft repeated examples of a lion heart in a little body.

A rescue that occurred in the early part of the war must have been one of the most dangerous for the medical and crash teams. It was on a Wellington Bomber station, in East Anglia. In the early hours of the morning the 'Wimpies' were returning from a night raid. The weather was bad and there had been many losses, so the station was on its toes to help damaged aircraft. One sadly crippled aircraft overshot, crash landed, caught fire and came to rest with one engine nacelle hanging through the roof of the bomb dump. Burning fuel was dripping on to the explosive stores below. The station commander and the medical officer arrived at the same time. They managed to rescue the entire crew.

This gallant effort is even more remarkable when the geodetic construction of the Wellington fuselage is remembered. If a crew member was trapped a way had to be hacked through a lattice work of dural over which the skin of the aircraft was laid. Considering how little there would have been left of all concerned if the bomb dump had gone up, I think the award of the George Medal to both officers was well merited.

From his entry into the service in September 1939, this doctor was at once popular with all ranks. Thickset in build, with curly fair hair and a massive square jaw he had the innate charm and delightful brogue of all that I have met who come from Cork. From the bomber station in East Anglia he was posted overseas to Singapore, arriving just in time to be captured by the Japanese. Just a few of his experiences are enough to show that his is a story on its own. The treatment for his wounds by the Japanese doctors included the removal of the head of the radius bone in his elbow without the customary solace of an anaesthetic. With scant regard for his professional status the Japs set him to work with the other prisoners, finally succeeding in reducing a fourteen stone man to seven. He was later shipped with other prisoners to work in Japan and one day out was torpedoed by one of our ships. Unluckily he was rescued after hours in the sea by an enemy ship and completed the voyage to Japan. His final adventure after months of menial work of all sorts was to experience the horror of the atomic bomb at Hiroshima.

Meeting him some years after the war for the first time since we joined together, he told me something of his doings which in itself was a masterpiece of understatement since he gained the O.B.E. for his services while a prisoner. His final remark is worthy of record as an example of modesty and sincerity to a point of naivety.

'Ye know, Bob,' he said, 'All this was not what I joined the R.A.F. for—I scarcely saw the war at all.'

After the war many of the doctors from the 'Lab' and the commands returned to civilian life and their own specialities.

Dr. Huins and Dr. McGown went back to their practices, Wing Commander Roland Winfield left as head of the Institute of Aviation Medicine to become a fellow of St. John's College, Cambridge. But for as many who left the service there were an equal number of those who decided to remain, and the pattern and spirit built up over the war years remained to be used in the aviation medicine of the jet and rocket aircraft era. Dr. B. H. C. Matthews was knighted for his services and though appointed Professor of Physiology of Cambridge University continued as Consultant in Aviation Medicine to the Royal Air Force. As the years passed a new generation of doctors took to the air as medical test pilots and flying personnel medical officers. Some of these were ex-operational pilots who, leaving the service after the war, qualified in medicine, and returned to fly once again, but this time as doctors. Their experience of flying against the enemy and often their many thousands of hours, enhances their status considerably in working for aircrew. Their task is not light for they must be qualified on the most modern aircraft whether fighter or bomber. The pioneer spirit of Corner and Robson and the others who followed is very much alive in the medical branch today. It is evidenced by a recent flight to Australia. Two doctors, the flying personnel medical officer of Bomber Command as pilot, and the Consultant in Radiology to the R.A.F., as a scientific observer, flew to Woomera in Australia in a Canberra. Their object was to fly through the mushroom cloud of an atomic explosion to collect samples and measure the radio-activity of the particles. They achieved this successfully and with their navigating officer became the first men in the Royal Air Force to experience the dark turbulence of an atomic cloud. They made an uneventful flight back to England and some time later both doctors were awarded the Air Force Cross.

6

Transport Flying

THE role of the transport aircraft and their crews has on the surface less 'glamour' than that of Bomber, Fighter and Tactical Air Forces. But as the war progressed their task became more vital not only in support of the armies but in the truly offensive, though unarmed, job of towing gliders and dropping paratroopers. In all theatres of war, as the allied attack intensified, the work of the transport pilots and their crews grew more arduous and dangerous. From the Western desert and North Africa, to Sicily and Italy until the final mammoth invasion of the Continent, the supply by air to the battle fronts, of vital stores and ammunition, and the evacuation of wounded, played an increasingly important part in the subjection of the enemy. In the Far East the support of Wingate's Chindits alone is an epic of splendid flying under the worst of conditions. The Dakota crews contended with such hazards as the Monsoon, flights over the 'Hump,' and faced the turbulence and ground attacks to fly through the valleys carpeted with dense jungle, to drop their supplies to our troops miles inside the Japanese lines.

The first R.A.F. doctor to make his main interest that of transport flying and its medical problems was the senior medical officer of 45 Group of Ferry Command. Ferry Command was the forerunner of Transport Command and this Group was at Dorval, the airfield near Montreal in Canada. Their work was the conversion of crews to the American types of aircraft such as the Liberator and Mitchell bombers which were being ferried across the Atlantic. The group had a responsible job, especially the Wing Commander Medical Officer. He had qualified in peace time for his wings but was one of those not content to fly elementary types. On top of his routine administrative and medical duties he paid particular attention to the problems of aviation as they were applied to transport flying. He made such subjects as fatigue, cold, in flight feeding, survival in the sea, and oxygen systems his special concern. He was, in fact, one of the first to devise a practical portable oxygen set for transport aircraft. But his main preoccupation and love was flying. A first class rugby player and all round athlete, he appeared, indeed still appears, to have an inexhaustible supply of energy and enthusiasm.

I met the Wing Commander in charge of flying at Dorval several years later, when he was commanding one of the Dakota squadrons operating into France from 'D' day June 1944 onwards. He recalled how the doctor persisted until he was allowed to do a conversion course on to the four engine Liberators and, if found not wanting, to ferry one across the Atlantic himself. The squadron commander went on that he had never seen a man work so hard. He had told the doctor that if in addition to his other duties he could work every afternoon for two months, and complete the necessary night flying, achieve a satisfactory standard in navigation, meteorology and signals, and familiarity with engines, airframe and fuel systems, he might be considered for a trip across the 'pond.' He thought that such a programme of work might well deter the doctor, but admitted that two months later he was well fitted to ferry a Liberator across the North Atlantic.

It is a measure of keenness and ability that a short while before the appointed day the plan was changed and our doctor instead had to convert to and fly a twin engined Mitchell across the southern route. From then on he went from strength to strength and completed several more Atlantic crossings as captain of Liberators, Mitchells and Dakotas. On one trip during the winter he made a search for the survivors of an aircraft that had ditched in the icy waters of the North Atlantic. He was successful and directed a rescue vessel to the spot in time to save them from dying of exposure. His longest trip, I think, was when he captained a Dakota throughout the whole flight from Canada, via Africa and the Middle East, to India. After a spell in a transport group in India he eventually became the flying personnel Medical Officer of Transport Command Headquarters in England.

I have introduced this chapter on transport flying with his story for two good reasons. First, that he was the first doctor to go deeply into the physiological and psychological problems of transport crews, and second, that his personal experience of thousands of hours of flying and the recommendations that arose from it were of so much help to me when I later took over from him. Later in the book I have included some experience of the Berlin Airlift where all the problems of transport flying were multiplied, none more so that that of fatigue. Of all the useful and valid reports and suggestions that he made while at Transport Command, I think of greatest importance was that on the limits to the number of flying hours that crews should do in any one period of a month, three months and a year. These have never been superseded and have served as a base line, not only in the Royal Air Force, but, I believe, in civil flying as well. That his criteria are as sound as when he first formulated them is, I believe, due to his determination to fly as hard as the transport crews and to experience with them their conditions of work in any part of the world, over continents and oceans, through the tropics and desert to the North Atlantic.

The evacuation of wounded by air, though getting off to a slow start in the early part of the war, became in the end one of the major tasks of transport aircraft in all the theatres of war. It was by no means a new concept, for a number of casualties had been flown out of Paris by balloon in the Franco-Prussian war. No serious effort was made in the 1914-1918 war to use aircraft to clear wounded from forward areas, but between the wars air ambulances were increasingly used in parts of the world where it was difficult to use other means of transport. Such major calamities as the Quetta earthquake of 1935 stimulated an improvised use of available aircraft to fly in medical personnel and stores and evacuate casualties out of the area. Only the Germans, as might be expected, made full use of the Spanish Civil War in 1936-1938 to practise casualty evacuation by air. They regularly flew the wounded from their Condor Squadron the 1,500 miles from Spain to Berlin. From 1939 to 1942 several abortive efforts were made to establish aircraft solely as air ambulances, which on each occasion were frustrated by the shortage of aircraft. It was only after the successful movement of many thousands of wounded men during the North African and Sicilian campaigns that the role became firmly established and preparations physical and administrative were made for casualty air evacuation whenever the inevitable invasion of the Continent became fact. The policy was maintained, as far as Transport aircraft were concerned, it would be freight in and casualties out. There would be no Red Crosses, for under the Geneva Convention no ammunition or other stores for war could be carried.

I do not intend to plagiarise other more able records than this, of the evacuation of casualties from the various war fronts, but briefly to give a personal impression of the value of such work. In 1944, after returning from Canada, I was posted to a Casualty Evacuation Unit for three months while waiting for the next step in my Pilot's course. R.A.F. Broadwell was one of three transport stations that were busily preparing for the tasks that they would perform from D-day onwards. The first was the dropping of the waves of paratroops at the start of operations, later towing glider-borne troops to land on an established bridgehead, and finally to fly in stores and essential personnel when airstrips had been prepared. It was when this phase was completed that the wounded could be brought out and flown across the Channel to base hospitals in England. It would be tedious to go fully into detailed descriptions of the administration and control of the casualty evacuation unit, and indeed it is my desire that part of this chapter should tell of the other members of the medical branch who also went into the air. I think many thousands alive today would be witness to the work of the nursing sisters and the women and men medical orderlies.

When I arrived about a month before D-day, June 6th, 1944, most of the unit had arrived: in all over two hundred personnel. There was a tremendous amount of preparation, planning and sorting out of equipment to be done and all hands were full every day of the week. Some fifty of the W.A.A.F. and R.A.F. nursing orderlies had received training in air ambulance duties before arriving at Broadwell, though, because of urgency and shortage of aircraft, painfully few had any air experience at all. This point worried me more than any of the other numerous problems and snags that must be solved before we were ready. It seemed very serious to me that we would be sending completely untried personnel in unarmed aircraft against an unknown opposition. Further, there might be some of them who would be airsick to the point of incapacitation. The answer was obvious; they must all be given at least a few hours' flying if only to weed out any unlikely starters.

Looking them over, I sincerely hope unnoticed, they appeared a keen and enthusiastic lot. About half of them were girls. They were already showing evidence of high spirits and a pride in being officially members of aircrew by their display of flying clothing, boots and other aircrew accoutrements. Many were sporting gaily coloured scarves in the manner of the more exotic fighter aces, and a few even swaggered round with air maps which I am sure they could not read, tucked in the traditional way into their flying boots. I was worried about how these 'kids,' for most were little more, would face up to the combination of the care of severely wounded men and flying on operations. As it turned out I need not have worried, but I still felt that despite my favourable impression they ought to be given some flying experience. I was successful at first in getting a few on to the Dakotas that were still flying, but very soon the station was 'closed' and no one could leave or enter, and at the same time all the Dakotas were grounded in order to be ready for the maximum effort in flying hours.

This security measure brought us very near to D-day. All that was left was the station Anson. It could be flown but not landed at any other station in accordance with the security order. With this I had to make do and with the help of one or two other pilots we managed to get the orderlies at least a few hours flying each, taking them on cross country trips six at a time. I had definitely over-emphasised the problem for all those whom I flew remained unconcerned and without a trace of airsickness. I was surprised for I think many pilots will agree that the back of an Anson can be in bumpy weather fairly 'sick making.' One night, passing the marquee that we had fitted out as a crew and rest room for them, my last lingering doubts faded as I heard a particularly robust rendering by my budding male and female aircrew of the Rabelaisian ditty 'Roll me over —.' They'll do, I thought, and how right I was.

At last the great day arrived, or rather the night before. Paratroopers from all regiments and corps of the army waited to emplane under the wings of the Dakotas. Faces blacked, armed almost literally to the teeth, these men, who had trained for so long for this moment, looked equal to any task. At last they were off into the night heading for France and the fields of Normandy. It was not to be for several days that casualties could be brought back by air. The Dakotas' next task was the towing of troop-laden gliders when the bridgehead had been further extended and controlled. I have never seen such jubilation in any station on the return of the glider crews, each comprising a pilot and second pilot and usually an army officer and N.C.O. Their orders were that as soon as they landed their Horsa gliders, they must make their own way if necessary through the enemy lines to the beaches. There they were to 'hitch' a passage in any vessel back to England, and the station to be ready to fly over another glider. Every single one of the crews from Broadwell arrived safely back within forty-eight hours. The affection and esteem between the airborne troops and the airforce personnel was very strong on these combined operational stations and a considerable but justified amount of celebration took place in the messes that night.

Despite all the excitement and work the days dragged by for the casualty evacuation unit as we waited impatiently for our chance to show what we could do. Most of the aircrews were not very happy about evacuating casualties, for rather naturally a more operational role was better to their liking in this all-out effort against the enemy. They were shortly to change their minds for they very quickly became mustard keen and vied with each other to have achieved the maximum number of lifts. It was not long after the first airstrips were built and the Dakotas had started to fly in vital stores, fuel and ammunition that we received orders for the first time to allocate an air ambulance orderly and his or her pannier to each aircraft.

One morning early we loaded up some of the ambulances with a number of airmen and airwomen and their gear and drove off to the dispersals to meet with the aircrews at their aircraft. I was anxious that crews should have no cause for complaint, particularly as regards delaying take off time. But despite the usually charming tendency of the female sex to have to 'see to some little thing or other' at the last moment, we succeeded in getting them briefed and on the right aircraft at the right time. We had received information that enemy fighter opposition was minimum and that our fighter cover was completely in control of the air situation. This, of course, made the operation much simpler for these orderlies. They had now to make their reputation on their supervision of loading and care of the patients in the air, and at all times never to affect the operational efficiency of the aircrew. As they took off on this, the first trip, I cursed, and indeed am still bitter with officialdom, that had decreed that under no circumstances should I be where I ought to have been—on the first aircraft to take off.

The first few trips were sufficient to remove all doubts in the transport crews' minds as to the value of the job and the mettle of the air ambulance orderlies. Their behaviour was reported to me as 'magnificent' by some of the normally matter-of-fact and hard bitten crews. They had been impressed by the coolness and efficiency of these young girls in caring for a Dakota load of casualties, many of them with the most harrowing wounds. In the early days a high percentage of these battle casualties were returned to England having only received first aid. Often severe wounds were only roughly covered with the familiar shell dressing. It was inevitable that this should occur before base hospitals could be set up in the battle area.

It was I think on the second trip from our station that an incident occurred that brought the air ambulance orderlies into the highest repute. The Dakotas had landed on one of the first airstrips to be laid down in the Normandy beachhead. The army motor ambulances were arriving with the wounded and unloading was going ahead under supervision of their air ambulance orderlies. Suddenly, without warning, the strip came under fairly intensive enemy mortar fire which fortunately was short-lived, being silenced by our own troops. The scene was described to me by the squadron commander over a restorative pint in the mess later that night. He particularly had doubted the wisdom of carrying women orderlies on operations of this kind and had been anxious as to how they would fit into a crew. He admitted to me with a rueful smile that as soon as the attack started he and his crew made for the nearest ditch and flung themselves into the bottom. In the first lull he peered cautiously over the top and looked towards his aircraft. There, still outside the aircraft and without any cover, the slight young girl who was the orderly on his crew was calmly caring for her patients and making the usual preparation for the return flight. All his scepticism turned in a flash to enthusiasm. Sometime previously before D-day he had half jokingly and half in earnest asserted that 'he wasn't having any ruddy women on his aircraft.'

This and other incidents, coupled with the splendid manner in which W.A.A.F. and R.A.F. orderlies cared for their patients in the air and on the ground completely changed the attitude of the aircrew. Their enthusiasm grew with every lift, and, as I remember, it was that squadron commander who instigated the stencilling of ambulance silhouettes on the aircraft fuselage to indicate the number of air lifts of wounded that had been flown. It seemed to me that the pilots and crews were no less proud of these symbols than were those of bomber and fighter commands of stencilled bombs and swastikas on their aircraft.

The first obvious advantage of casualty air evacuation to the Army commanders in the field was the relief of the burden of wounded in the battle area. Probably of no less value was the effect on the morale of the fighting troops of which we received an increasing number of reports. It gave great heart to those battling for a sure grip on Europe to know that if they did 'stop one' they might within a few hours be safely under treatment in hospital in England. Many were the occasions when a man wounded in the front line has been in hospital at home within six hours. Of even greater importance than the tactical gain and that in morale was the decrease in mortality afforded by airlift to base hospitals. An instance of this as I observed it was the comparative death rate from wounds to the head. Approximately seventy per cent of all head injuries in the 1914-1918 war proved fatal. Because of the proximity of Broadwell to Oxford and its famous head injuries centre all cases of this kind were routed through our station rather than through either of the two other casualty air evacuation centres. Until the time I left Broadwell, of the three hundred odd of these cases that returned from France only ten had died, a truly remarkable difference, which was occasioned by the speedy delivery of the patients to the skilled hands of specialist brain surgeons. These troops with head wounds presented the air ambulance orderlies with the worst problem of the airlift, for the more serious were often violent and deranged. I was repeatedly amazed that one young orderly had been able to control and soothe a load of such difficult patients and deliver them safely into the waiting hands of the nurses and doctors on the ground.

The day that remains clearest in my memory of my short stay at Broadwell was one on which we had the greatest number of casualties landed at one time. We were perhaps fortunate that being so far away from the main ambulance pool that collected the cases from the other two airfields for despatch by ambulance train to hospitals all over the country, we were allotted more than thirty ambulances of the Red Cross with their women drivers. These were permanently based with us and helped to swell our station resources for clearing the patients from the aircraft to the station sick quarters and the tented wards. The girls who drove these Red Cross ambulances were a magnificent team in every respect. No task at any time of day or night was ever too much for them or succeeded in dimming their cheery willingness. It was my sad duty on two occasions to be the first to announce the death in action of the drivers' husbands. The reaction of both girls was typical of the spirit of the rest in that they refused my suggestion of some leave and each in her turn left my office with head held high to return at once to their invaluable work. I record the Red Cross work particularly for it was their large number of vehicles added to the much smaller number of R.A.F. ambulances that enabled us to unload from the aircraft later in that day over four hundred cases in less than twenty minutes, a rate of twenty patients of all degrees of severity every minute.

The day began true to the pattern of numerous others that were scheduled for casualty evacuation. The aircraft at dispersal already loaded with stores were due to take off at 0730 hours. As usual it was necessary to allow at least an hour and a half before take off to brief the orderlies, sort their gear and deposit them at their aircraft. This was one of the occasions that I was going along, officialdom having relented, and was flying as second pilot to one of the squadron commanders. After briefing with the crew in the operations room we climbed aboard the transport and drove through the peaceful clear summer morning to the aircraft. With the sunlight striking tinder sparks from the early

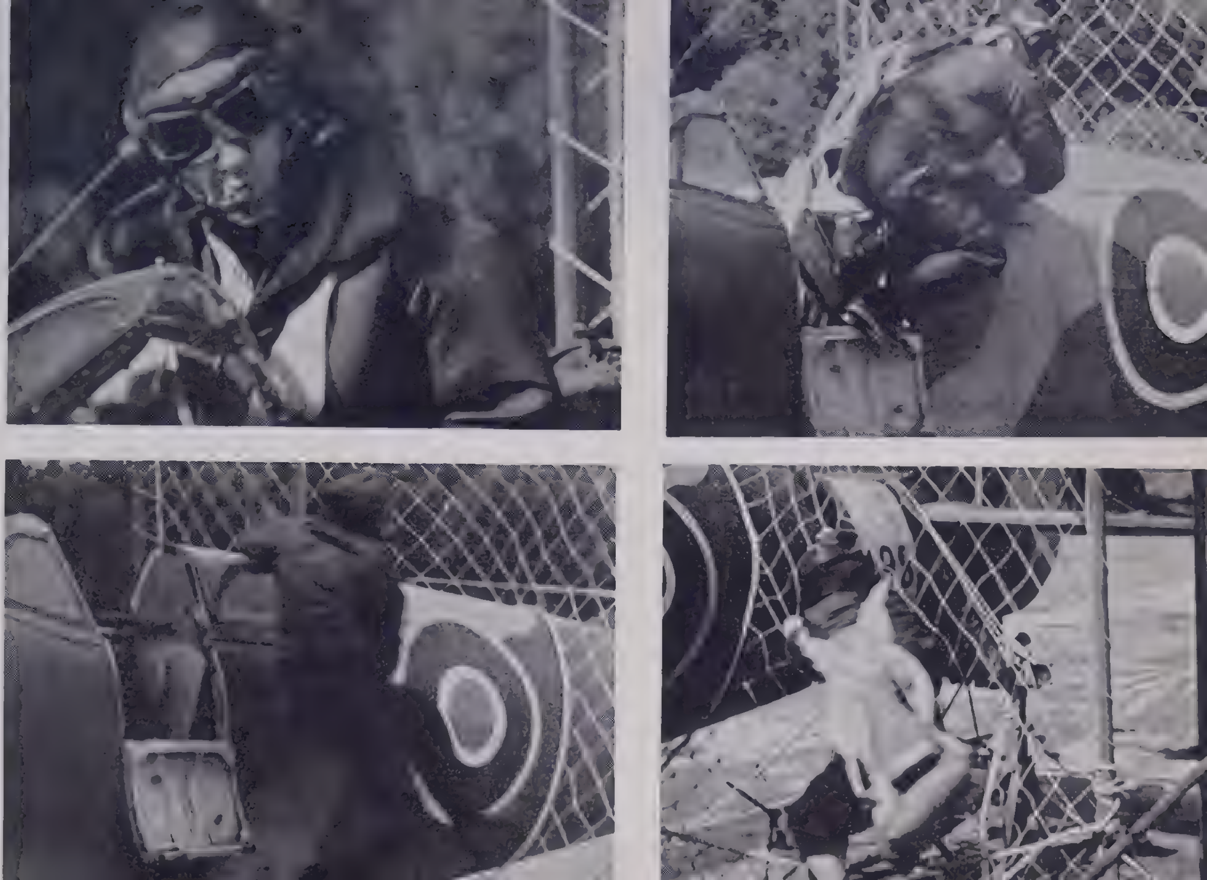


PLATE 10

The effect of high wind blast on a pilot escaping from an aircraft: the top left picture shows the distortion of the soft tissues of the face as the pilot rises above the protection of the windshield. These experiments took place from a plane placed in a wind blast on the ground and the net is there to catch the victim.

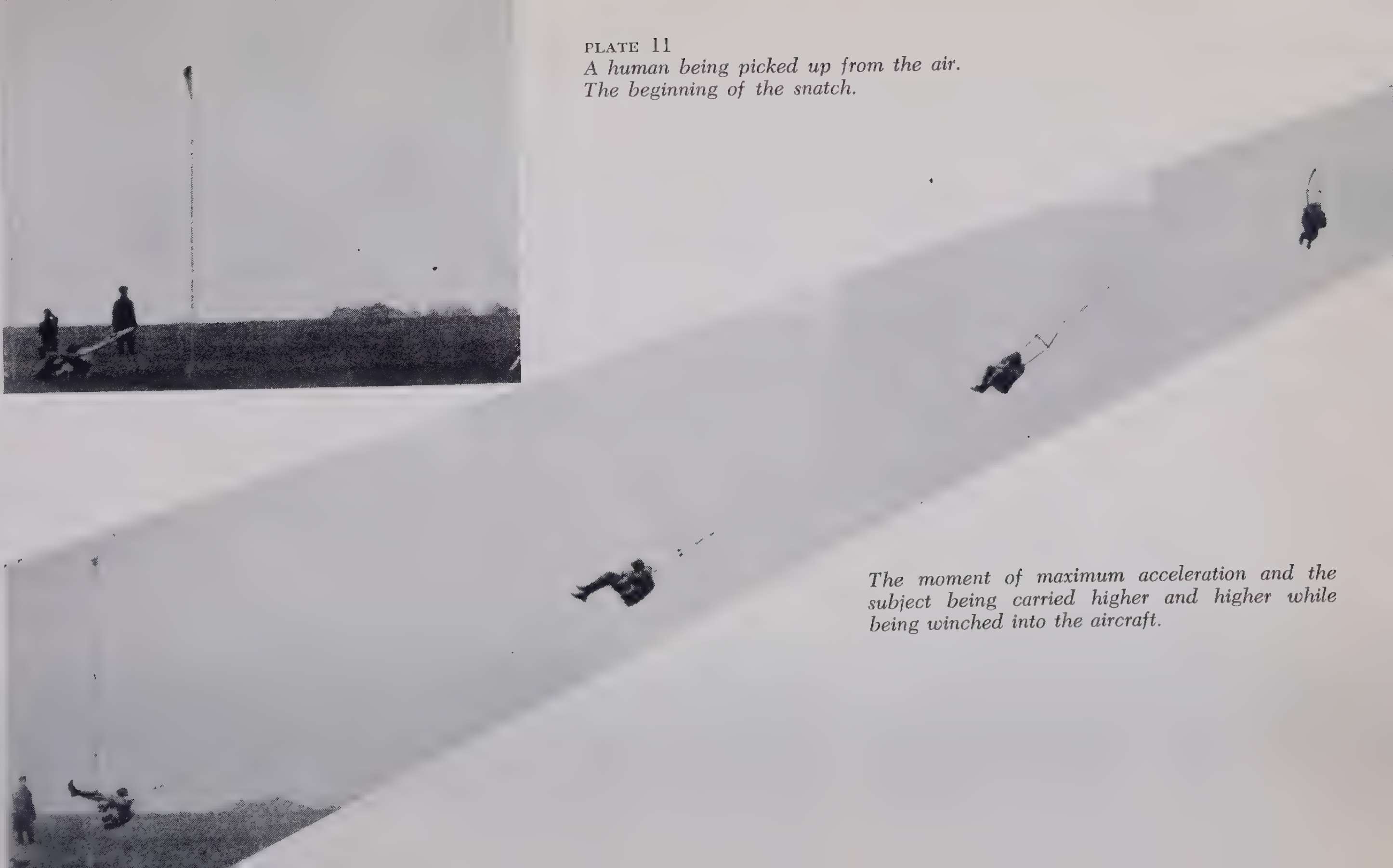


PLATE 11
A human being picked up from the air.
The beginning of the snatch.

The moment of maximum acceleration and the subject being carried higher and higher while being winched into the aircraft.

morning dew it seemed impossible to imagine our armies and airforce fighting a grim battle so short a flight away across the Channel. After starting up and taxying out, in a few minutes twenty Dakotas were airborne and headed towards the coast. We had to be at an appointed position on time to rendezvous with fighter aircraft which formed a cover for all these air transport convoys. Soon we were approaching the now familiar, though to me always miraculous, outlines of the 'Mulberry' harbour. Turning in over the beach-head, our wheels already lowered as a routine method of identification to the Navy and Army gunners, it seemed looking down that every field was full of thousands of tons of stores. Transport vehicles and tanks of all descriptions crawled along the roads tracked by clouds of dust. And further away the gun flashes of battle made real the double purpose of the transport crews' work.

'Freight in and casualties out.' The wheels rumbled and rattled on the perforated steel plate airstrip and we were down. The ground crew marshalled us into our appointed positions off the strip whose prime function was still to serve the ground attack Typhoons of the Tactical Air Force. The organisation of the young squadron leader medical officer and his staff under such conditions was masterly. Earlier on, it had sometimes been bitterly disappointing when the aircraft had had to return empty to England. For they were always committed to the rendezvous with their fighter cover and if the ambulances had been unable to arrive at the correct air strip in time then it was all off for that day. All went well on this particular sortie and a seemingly endless stream of ambulances moved from the air evacuation centre nearby to load the aircraft. Finally the last ambulance left, doors were closed, engines started and the twenty Dakotas taxied one at a time to the end of the airstrip for take off and the flight home.

As soon as we were airborne I went back to see how things were with the patients. Most of them, whether sitting or lying, were silent and even morose. Grey with fatigue and a coating of Normandy dust, they had had for a while as much as they could take. Nearly all had lost their kit and personal belongings and this with their recent experiences appeared to give them an outlook as grey as the dust on their torn and stained uniforms. The W.A.A.F. nursing orderly moved quietly among them administering to their needs with the assurance of a woman twice her age. For her the men managed to raise a smile and forget for a brief space the loss of friends and the grimness of the battle.

The coast of England and the approach to land at Broadwell served again to relieve their indifference as they queried the position and how far they were from the various towns and cities that were their homes. On the ground the aircraft moved into a wide semicircle on the large concrete loading space facing the forty odd waiting ambulances which, as the engines stopped and the freight doors swung open, moved forward towards the aircraft. In pairs they backed up to the fuselage between the tail and mainplane. The unloading teams were at the ready and stretchers came off in a steady stream and into the ambulances. Back in the wards the chief surgeon and his assistants were examining and checking the wounded and deciding on their dispersal. The walking wounded were taken to separate huts fitted up with comfortable chairs, books, magazines and desks. It was this time of the day, usually later afternoon or early evenings, that the grand spirit of the whole station was exhibited.

Although it happened time and again it was always a source of wonder to me to see the selflessness of our nation when really challenged. From the very first load of patients we received, airmen, airwomen, N.C.O.'s. and officers would come from all parts of the station to help with the wounded. Nor was it idle curiosity for, tired though they were from hangar, workshop and the flights, they never left until the last patient was comfortably in bed in our wards or the last ambulance had left to meet the hospital trains at the railhead. It was wonderful to see how quickly nurses, orderlies, and their volunteer helpers restored to these weary and dispirited men a new interest in life and the ability to laugh and joke again. It was a heartening scene in the huts to see these wounded men washed and shaved and fed a great dish of eggs and bacon; then aided to write letters and telegrams to their relatives; and finally, before they left for the train, kitted up with all the trivial little things so often taken for granted. It gave them pleasure and a regained feeling of security to receive from the abundantly generous Red Cross stores razors, soap, toothpaste, writing pads and the ever necessary handkerchief. Once again they had become men of possessions. They were clean, fed and home. Life had started up once more and the grey cloud drawn from the future which if not rosy indeed held possibilities.

Thus a typical day in the life of a casualty air evacuation unit started at six in the morning and rarely finished before ten at night, only to be repeated the next day and the next.

7

To Fight Another Day

AN orderly retreat, strategically timed, has always been good military practice, and the resulting ability to fight another day has often achieved victory in the final battle. The implications of such policy, in aerial warfare are more complex than for army forces. Aircrew in their efforts to evade and escape, which is their duty, do so, if not alone, in small parties, having only the aids which could be carried in the aircraft they have left. Their first need is to survive in order that they may evade capture and perhaps reach friendly territory from which they can again fly against the enemy. Whether they have abandoned their aircraft by parachute or through a hatch on to land or sea, what they are wearing and can carry with them might be deciding factors in the success or failure of the attempt. Food and water, drugs, protection from the elements and methods of location, all these have physiological implications which have been a constant concern of doctors in the 'Lab' and in the field.

One of the early problems was that of protection against the icy waters of the North Atlantic in winter. As the submarine warfare intensified and the toll of ships mounted an added German threat was imposed on our convoys. The enemy, by now masters of Norway and France, launched an attack from the air on our shipping which was far out in the Atlantic and unprotected by our short-range fighters and medium bombers. This they were able to achieve by using a very long range four-engined bomber, the Focke Wulfe Condor, which, taking off from Norway, flew out to attack the convoys and landed eventually in France. Anti-aircraft fire was found to be inadequate against the Condors and the ships were more or less at their mercy. To counteract this situation catapult aircraft on merchantmen or C.A.M. ships were brought into use. A fighter thus shot off the deck of a merchant ship was able to destroy or drive off the bomber by virtue of its greater speed and manœuvrability. But the significance of the operation was that for pilot and aircraft it was a one way trip. After the engagement had been broken off the aircraft was committed to end in the sea for it was far out of reach of any land and obviously could not land on the ship as it might have done on a carrier. The authorities considered the cost of an aircraft well worth while if it saved one or more merchant ships and their vital cargoes with perhaps the added bonus of an enemy plane destroyed. The pilot, faced with the choice of baling out or ditching, also ended in the sea, but he was not expendable. The time taken to pick him up varied and might be as long as thirty minutes. In the North Atlantic in winter the temperatures of the water were such that very few minutes would need to elapse before the man died of exposure. This then was the problem which had to be solved. Some form of suit and material must be worn by these pilots which would protect them for a sufficient time for their rescue to be effected.

This project became the special province of Squadron Leader E. A. Pask. The first thoughts on the type of material which could be used were based on the necessity for the fabric to 'breathe.' There was at that time none available and natural material was considered. It was thought that the most likely to fit the requirement would be some kind of leather. Advice was sought from the research experts in the industry who suggested that horse leather might be suitable. Skins of the right quality when passed through the tanning process, retained open pores which closed on immersion in water. This appeared to be a possibility for when worn ordinarily as a flying suit it would allow the passage of air and water vapour from perspiration. The first suits to be made up were a marked success and the question of quantity production was faced. When looked into it was found that the supply of the high quality skins of the right thickness was very limited and would be quite insufficient for the numbers required. The selection of the skins available was critical and a high percentage failed to pass the test. Another material had to be found to fulfil the requirement. Mr. Howard Franks, then working at the Ministry of Aircraft Production, is a man with a wide knowledge of the textile industry and cotton research. Dr. Pask and Mr. Franks in their search obtained samples of a material which hitherto had been used to make portable water tanks. It had the same property of breathing as horse leather and it was available. The first pieces were made into sausage-shaped bags which succeeded in sustaining an equivalent water pressure of four feet without leakage. Suits were made though not without considerable difficulty in the design of the seals at neck, hands and feet. A high tribute must be paid to Mr. J. Silverstone of Frankenstein's for his work in the solution of the problems of tailoring the fabrics, and the rubber technology involved. It is fair and indeed right, to say that today no two men bear a higher reputation in the field of development of personnel equipment and survival aids for aircrew. The first suits with attached rubber boots were given stringent tests by Dr. Pask under severe conditions. He, like all the other members of the Farnborough team, never spared effort on himself in experiment and trial. The efficiency of the suit can be judged by an amusing story of one of these tests. He had taken the suit up to the Shetlands in the depths of winter so that he could try it under the rigorous conditions of the Northern waters. He was taken out to the open sea by a Royal Air Force launch, and jumped over the side, wearing suitable flotation and prepared to remain in the water until it began to penetrate the fabric of the suit. The trial had to be terminated before this point, because the crew of the launch could no longer tolerate the intense cold! By this time the convoys were increasingly protected by long range air cover and the need for C.A.M. ships ended. However, service trials were carried out in Bomber Command and the Navy. Bomber Command thought they had no real need for it, but the Navy adopted the suit and proceeded with further development. It is an operational necessity today for those flying from carriers, where similarly there may be delay in rescuing any 'ditched' pilots from the cold sea.

Air warfare over the sea provided many other problems of survival, which could be solved only by the physiological approach. After work on the immersion suit those concerned with survival turned their attention to two of these problems; flotation of the body in water by life jacket, and resuscitation of aircrew rescued from the sea by the Air Sea Rescue launches around our coasts. Of first importance was the improvement of the life jacket, or 'Mae West'—so named because of the generous contours of the first models of inflated air bladders. The property of flotation and the efficiency of a life jacket varied with the type of material such as cork or kapok of which it was constructed, and naturally with the amount used. The more cork or kapok incorporated the greater the flotation achieved. Large bulk was however undesirable and even unacceptable in aircraft cockpits particularly in the small working space of fighter pilots. It was for this and other reasons that it became evident that the best method would be to inflate bladders in the life jacket with carbon dioxide from a small attached bottle. This system could be triggered off by the wearer in emergency but at all other times the 'Mae West' would be flat against the body and prove less of an encumbrance. One very important point had to be considered in the testing of the prototypes. The flotation while being adequate had at the same time to support the body of an unconscious or weakened man in a position where his nose and mouth were clear of the water. The floating position and behaviour of the conscious body is quite different to that of the unconscious, and to discover the correct distribution of the flotation areas was the problem presented. A large tank borrowed from industry was used in the original trials of the life jackets. Later on an indoor tank had been built in the 'Lab' especially for this kind of work. Windows were let into the walls in order that the floating position could be observed below the water line. Squadron Leader Pask was in charge of this project, and in order to resolve the problem of supporting the unconscious body he designed an interesting and rather complicated experiment. He proposed to use himself as the subject who would be anæsthetised and whose position when unconscious could be observed as he floated in the water.

The experiment needed carefully setting up and certain difficulties had to be overcome. The trickiest of these was to prevent water entering the lungs of the unconscious subject. This was achieved by using an endotracheal tube to administer the anæsthetic. This meant simply that the first stages of anæsthesia were achieved with the customary mask over the nose and mouth but later a soft tube was inserted through the nose, down the throat and into the windpipe. This tube was then connected to the anæsthetic machine and the gas continued to flow into the lungs. Around this endotracheal tube was a cuff which could be inflated and thus obliterate the airspace and exclude any water. When all was ready and the apparatus had been set up to record pulse and breathing rates the subject was thrown into the tank. There was nothing flamboyant about the throwing, since this method of entry simulated jumping from a 'ditched' aircraft or landing from a parachute. It also ensured that the body sank initially, so that observers could note how the particular life jacket on trial behaved and whether it brought the subject to the surface in the correct floating position. The experiment was carried out on two occasions, both times for several hours, during which time many different types of jacket were evaluated and in each case the floating position was photographed from above and below the water line. The information resulting was of the utmost value in the design of the inflatable 'Mae West' and the principles elucidated have been used in the development of life jackets to the present time.

An allied problem to flotation was that of revival or resuscitation of pilots and aircrew rescued from the sea, and who from exposure or injury or both, were often in a very poor condition. It was desirable to obtain information which would produce the best methods of treatment and artificial respiration to apply to these survivors. To obtain this first-hand proved very difficult for though numerous trips were made on the air sea rescue launches, it became obvious that it would take too long to build up a series of cases on which the desired principles could be based. As in the experiments on flotation the use of anæsthetics helped to resolve the problem. As this subject was Dr. Pask's particular speciality, he again designed the experiment with himself as the subject. The object was to discover the most efficacious method of artificial respiration and if possible to get some idea of how moribund a survivor could be and yet be resuscitated. To achieve this, it would be necessary for the subject's breathing to have stopped. The drug used was curare which is the paralysing element of the South American arrow poison. It can produce varying degrees of paralysis depending on the strength of the dose. In large doses it causes paralysis of the muscles of respiration which was necessary for the experiment. This of course would result in death if some means of artificial respiration were not applied. Curare has also another unpleasant property for, while producing complete helplessness before death, it does not cause coma or unconsciousness, and the mind is left clear and unclouded. To avoid the mental distress this would impose on the subject, it was decided that he should be anæsthetised for the period he was under the influence of the drug. A colleague of Dr. Pask's who was assisting, recalls that despite the scientific and unemotional conduct of the experiment, the atmosphere became tense as for many anxious hours artificial respiration was applied to the paralysed and unconscious subject, until the effect of the curare began to diminish. During that time recordings were made of blood pressure, pulse rate and other data of physiological import which helped to lay down principles of artificial respiration which could be applied in practice in the confined and difficult conditions of an air-sea rescue launch.

The experiment is also a valid example of the many occasions on which marginal risks have been taken by scientists unobtrusively behind closed laboratory doors.

I have touched only briefly on some of the aspects of survival and the descriptions of experiments give little indication of the meticulous and accurate scientific work that was involved. Throughout the war members of the staff of the 'Lab' were occupied in patient research into the development of clothing, survival rations and aids which would ensure aircrew the best chance to live and be rescued from desert and jungle, tropical seas and arctic wastes.

After the war, though the personalities changed, work on all aspects of survival went on unabated. The prime considerations in this subject can be thought of under four broad headings; protection, location, water and food. If a man is to survive whether on sea or land, in hot or cold climates protection is the first essential. The work in this sphere included the development and testing of any item that provided protection against the elements whether it was special clothing or the fundamental protection of flotation by 'Mae Wests' and dinghies. Assuming a pilot to have successfully landed on the sea by parachute and then to have inflated and climbed into his dinghy his next requirement is some means of attracting the attention of aircraft and ships. To this end the selection and stowage of the most reliable methods of location had to be considered. Amongst the items used were signal flares, whistles, heliographs and the bright yellow colour of the dinghy itself. Water and food are obvious necessities, but the space in the aircrew survival packs being limited, careful consideration and trials under realistic conditions were necessary to discover the balance between food and water and the type of food which as well as sustaining proved acceptable to the palate.

Several fairly rugged field trials were carried out by members of the 'Lab' staff in terrain varying from the dry cold of northern Canada and Norway to the wet cold of Alaska. One of the earlier cold weather trials was made in Norway. Three doctors from Farnborough flew to southern Norway where they set up a base in a hut on the slopes of a 3,000 foot mountain. The senior member of the team flew the 'Lab's' Mosquito across himself carrying all the equipment necessary for the trials. He also experienced for himself the difficulties of operating aircraft under cold conditions. The Mosquito made landings on both snow and ice runways sometimes with cross winds up to 30 knots from 40° off the runway. Experience was also gained on landing Royal Norwegian aircraft fitted with skis instead of wheels. Attention was paid to the difficulties of the ground staff when servicing the unprotected aircraft. One valid point that arose from the team's recommendations was that a man must first be able to control his own physiology and provide for his own locomotion over the snow and ice before he can fly or look after aircraft. At the same time as this work and during the twelve days of the trial the items of survival equipment were being tested under rigorous conditions. For several days the team lived only on the monotonous rations that a survivor would have with him. They built igloos and fashioned shelters from parachute canopies. Sleeping bags were tried to the extent of sleeping out of doors in a blizzard. Not the least of the discomforts was donning skis to go to the latrine two hundred yards away from the hut. Valuable information from this trial added to our knowledge of how to survive in extreme cold and helped towards the development of a range of cold weather clothing which subsequent trials have proved unequalled throughout the world.

Sometime later a member of the 'Lab' joined an expedition to the tip of the Alaskan Peninsula at the eastward extremity of the Aleutian Islands. The team on this occasion was international and the members were drawn from the Royal Air Force, Royal Canadian Air Force and the Air Force and Navy of the United States. The object of trials this time was to test equipment and methods of survival in a wet and cold climate. The conditions of the trial were realistic and harsh and presented the problem of living and keeping dry and warm in weather consisting sometimes of torrential rain with winds up to sixty miles an hour and temperatures only a few degrees off freezing. The squadron leader from Farnborough tried out the other countries' equipment as well as our own, and with few exceptions the range of clothing, survival aids and rations came through the test. The team also carried out trials on sea survival in water but a few degrees above zero. Of particular interest was a trial on the Royal Navy immersion suit, which was a development of the original suit made for the C.A.M. ships. This squadron leader succeeded in staying in these chilly waters for sixty-five minutes supported by his 'Mae West.' This is a remarkable triumph for the British cotton industry which produces the ventile fabrics of which the suits are made. The information from these trials was again invaluable in providing principles on which to improve and modify existing pieces of equipment and design and develop better items.

Part of the pattern of survival in many cases is the parachute. Initially it is of first importance and is followed by the other aids I have been discussing. I mentioned, in the introductory chapers, Leonardo da Vinci's interest in the subject. Blanchard, one of the early balloonists, experimented in 1785 with dogs, dropping them attached to parachutes from his balloon. He later made a successful descent himself though he unluckily broke his leg. In the 1914-1918 war parachutes were increasingly used in the latter years and saved many lives. Many members of the Royal Air Force Medical Branch and doctors of other countries' medical services have been closely associated with the problems of jumping both from an aircrew and airborne troops' point of view. When in 1941 the training of airborne troops was started on a sizeable scale an R.A.F. medical officer was posted to the Airborne Forces Establishment in this country. He was an expert parachutist and significantly the younger brother of Wing Commander Winfield whose ubiquitous exploits I have mentioned in another chapter. Roland Winfield himself made numerous jumps from balloons and aircraft. B. J. O. Winfield's duties at the training establishment were to advise on parachuting from a medical aspect and for this purpose to liaise with the Army and the Institute of Aviation Medicine. His research on the subject showed that the main factors in liability to injury on landing by parachute were age, weight, force of wind and the type of terrain. The statistics revealed that injuries were more frequent in those over 25 years of age and that the injury rate rose rapidly in those over twelve stone in weight, a point which might be remembered in connection with a slight personal reminiscence later on in this chapter. Naturally, the stronger the wind the greater was the risk of injury from the wrong stance on landing. Winfield made a study of the commonest part to be injured, and as might be expected it was the legs. He also ascertained that initially four per cent of troops received injuries during training. His research and personal experience resulted in suggestions to improve the attachment of the parachute harness and correct stance on landing. Subsequently these changes led to a reduction of injuries to 0.5 per cent of jumps during the training period. In addition a considerable amount of work was done with different types of parachute to ascertain the most foolproof, both as regards certainty of opening and minimising the final deceleration on touching down.

The elder Winfield's avidity for adventure and what seemed to be a proclivity for dangling in space at the end of a cord involved him in a hazardous piece of work which was carried out at the 'Lab' towards the end of the war. For some time agents had been dropped by parachute into enemy territory to contact resistance groups. They were on occasions picked up again but the difficulty of landing an aircraft to achieve this led to the need for a technique of snatching the body from the ground. The problem was how to accelerate a man from rest on the ground to 120 m.p.h. in the air. The squadron leader who had done so much of the work on accelerations and decelerations which comes in the chapter on 'G,' worked with Roland Winfield on the project. Between them they did most of the physiological work and were the subjects for the original snatches. Experiments were carried out at overall accelerations of 5—7 'G' during the space of about half a second, the subject going from rest to the speed of the aircraft before being hauled into the cabin during flight. The technique they developed showed that a man could be picked up with safety if he adopted the correct position. The procedure went as follows. The subject sat crouched on the ground, head well tucked into the chest and his back to the line of aircraft flight. He was positioned between two twenty-foot high poles supporting a nylon loop, which in turn was attached to the man's harness. The aircraft flying with extreme and necessary accuracy went over the poles and a drag hook on a rope hanging from the plane engaged in the nylon loop. On one occasion Winfield nearly lost his life when the hook only half engaged with the loop but fortunately held its position long enough for the unsuspecting subject to be hauled into the aircraft.

There were other problems for solution in parachuting, particularly the emergency escape from aircraft at high altitudes. It was not known for instance whether a man would survive if he baled out at altitudes over 40,000 feet, faced as he would be with the twin hazards of extreme oxygen lack and intense cold. To resolve this problem of anoxia members of the 'Lab' staff took part in a number of experiments to find out how long a man could live at heights varying between 44,000 and 25,000 feet during parachute descent, even though he was unconscious. These experiments, which even the unemotional records refer to as dangerous, were done in the laboratory with the atmospheric oxygen conditions from 40,000 feet down, simulated by breathing a nitrogen-oxygen mixture which could be varied as in a true descent with an open parachute. The subject was suspended by the normal parachute harness and the gas administered through a tube and mask. It was found that a man could remain unconscious and yet live for a period of up to 7½ minutes. This however would not ensure a safe descent for it would take at least this time to descend 35—20,000 feet. Moreover, the head of the unconscious man would be slumped forward, causing probable obstruction of breathing. The intense cold, not experienced in the laboratory, would further reduce his likelihood of living. To do a delayed drop from 35—20,000 feet which would take 1½ minutes was no solution, for at that time the man might be so anoxic that he would not recover in time to pull the ripcord. From this work it became evident that at these altitudes the escaping aircrew would need an oxygen supply outside the aircraft. A bale-out emergency oxygen set was produced later which lasted from 10—12 minutes and greatly increased the confidence of those flying at great altitudes.

The other problems of high altitude bale-out was that of the high forces of deceleration imposed on the man when the parachute opened. A high tribute must be paid to the American workers in this field. Early experiments carried out by Colonel R. Lovelace and M. W. Boynton, highlighted the two extreme hazards of the opening shock of the parachute and exposure to cold. One of Colonel Lovelace's many jumps was made from a Flying Fortress at 40,000 feet. The shock of over thirty-three times body weight was sufficiently severe to injure him and cause him to lose consciousness, and the slow rate of fall—taking 22 minutes to ground level—exposed him to temperatures as low as −40° C., resulted in his admission to hospital with badly frostbitten hands. In another of these gallant experiments M. W. Boynton lost his life.

Much work of a similar nature has been carried out in America since the war. It has been notable for the magnificent bravery of expert test parachutists in actual ejections at all speeds upwards and downwards. Delayed drops have been made from well over 8 miles up and down to less than 2 miles. The story of bravery associated with medical investigation devoted to increasing the chances of survival of flying personnel cannot end without tribute to Lieutenant-Colonel Paul Stapp. This American doctor has travelled over the ground faster than any other man on his rocket propelled trolley, experiencing higher decelerations than ever before imposed on the body in the cold-blooded investigation of the strength of his body under great and sudden shock loads. A friend of his described him to me as a man whose bravery matches the research on the effects of very high speed ejections, which is so costly, that only American resources could undertake it.

In this country after the war a number of medical officers took parachute courses and some of them kept in practice by regular jumps. When Sir Philip Livingston became Director General of Medical Services his enthusiasm and energy in promoting the evacuation of wounded and ill persons by air led in turn to the introduction of parachute courses for complete medical teams. There was no shortage of volunteers and regular courses at the parachute training school were soon in full swing. A team consisted of a medical officer, a nursing sister and nursing orderlies. Special packs to carry medical and surgical equipment were devised. Doctors, nurses and orderlies were trained and kept in practice by regular refresher courses, so that they could be called upon at any time to form a team to jump to the help of injured personnel in inaccessible places. This applied particularly to the Middle and Far East where medical help might be many days reaching the survivors of a crash in desert or jungle. I can vouch personally for the keenness of these trainees since at the time I was as Flying Personnel medical officer responsible for the administration of the courses at Transport Command. When courses were going on I visited the station to see how the teams were faring.

I had previously, on one of my visits to the school, talked to the chief parachute instructor, with a view to completing a course myself. To be frank I was not exactly fighting for it, but thought that I ought to follow medical tradition and the example of young nursing sisters and junior doctors who were jumping daily. After studying my general profile and bulk he opined thoughtfully that were he to have me on physical training for three months he reckoned I would still break plenty of bones on my first jump and so the answer was 'No.' I tried not to look relieved and thought that was

PLATE 12
Loading casualties into a Dakota aircraft during the invasion of Normandy. Note the W.A.A.F. Air Ambulance Orderlies.

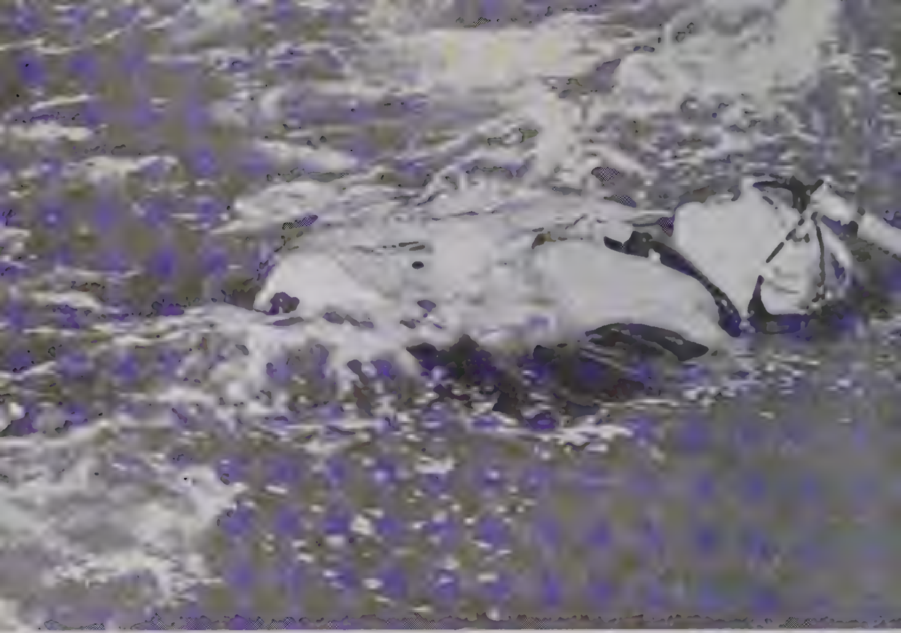
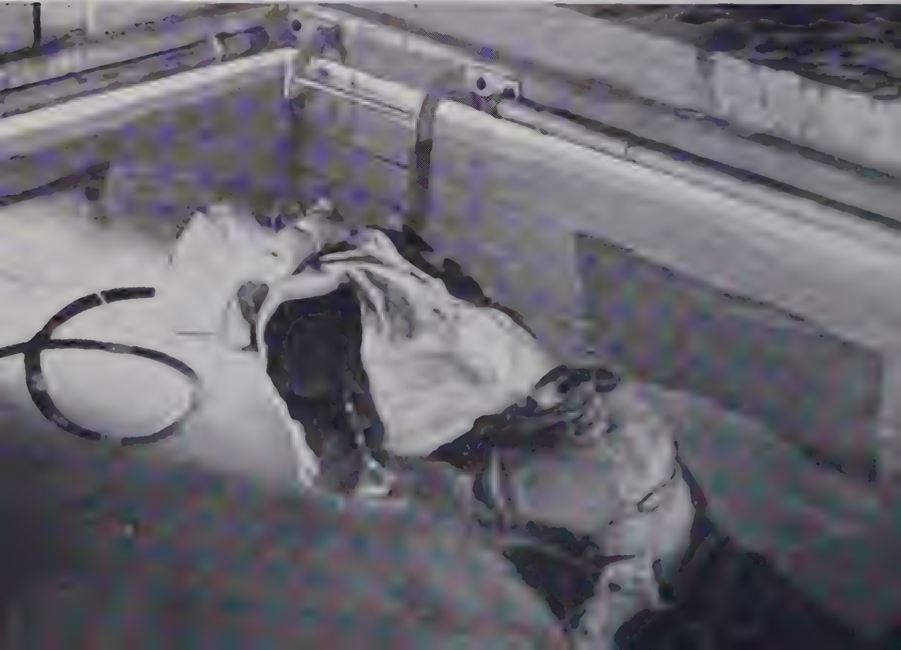


PLATE 13

Fully unconscious subject being used to test the flotation properties of 'Mae Wests'. In the lower picture he has been turned face downwards and the 'Mae West' is just commencing its life-saving operation of turning his face into the air. (Note the pipe used to maintain anaesthesia).



the end of the matter. I took a small measure of comfort from the fact that quite a number of pilots consider that it is time enough to jump when you have to in 'anger.' On my next visit the senior medical officer of the station announced with a roguish grin that he had overcome the problem of my weight by including me in the next party to jump into the Southampton Water. I thanked him for his thoughtfulness! Nevertheless I was rather pleased with this solution, for thinking back to General Armstrong's clear and factual record of one of the jumps he made in 1935, I thought it a good thing to experience the sensation for myself. The afternoon before the day of the water jump I spent in the training hangars. Here I was suspended in the parachute harness. The main thing to learn was the undoing of the straps around the thighs when clear of the aircraft and after the parachute had opened. This ensured that when entering the water, raising the arms would slip off the rest of the harness and avoid the danger of one's becoming entangled in the rigging lines. The other lesson to learn was the correct rigid stance and method of exit. In this kind of jumping there is no ripcord to pull, as the 'chute is pulled open from a static line in the aircraft. The next morning I woke over-early, and must confess that my usual appetite for breakfast was absent. I also made a mental note that my customary verbosity had dried up as well! However, once the Dakota had taken off for Lee-on-Solent, self-confidence was restored. At the Naval Air Station we landed, changed into overalls and gym shoes and donned our parachutes. We climbed back into the aircraft and were allotted our correct positions and order for jumping in sticks of two. When all was ready, we took off and climbed up over the sea. It was a grey September day with rain falling from low cloud at 700 feet. Over the appointed dropping area I looked down on the launches waiting to pick us up. A parachute instructor stood at the door ready to give the order to jump. I was in the first stick of two and had taken up my place at the open door. The lights flashed, the instructor yelled above the roar of engines and wind: 'Red on! Green on! GO.' I went. I am afraid to relate that I am unable to substantiate any of General Armstrong's clear and factual records of his physical and mental sensations. The whole thing seemed to be over before there was time to do anything. I certainly did not have time to enjoy the thrill of floating down for I spent all the time wrestling with those accursed thigh straps which clung tenaciously to my outsize beam and would not come undone, so that I arrived in the sea rigging lines and all. One thing I do recall is the effect of my weight on the speed of descent. Number two of my stick was an army officer of slight build and it is significant that he was still gently floating down while I was climbing aboard the launch. Despite the failure to record anything of use, it was well worth it if only for the splendid euphoria the outing produced. On second thoughts this was probably not unconnected with naval hospitality later on in the wardroom.

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The Berlin Airlift

THE Berlin Airlift, or to give it the official title 'Operation Plainfare,' has been the subject of books, stories, a film and television plays. For those interested in the precise details and dates there are the official records. I am recalling this enormous air transport operation, for it remains unique in peacetime, as a study of the effect on aircrew of intensive flying and difficult ground conditions. In the first instance only a small part of the force of Transport Command was detached to Germany. At this time Fassberg and Wunsdorf were the B.A.F.O. aerodrome used as bases. These aircraft although in Transport Command came under the control in Germany of the local Air Commander-in-Chief. Very soon after the start of the operation the D.G.M.S. sent a wing commander from Farnborough to Germany to study aircrew conditions with particular reference to flying fatigue. Every week more squadrons were taken off their normal 'route' flying to the Middle and Far East and sent to Germany. About the time that the doctor from Farnborough, himself an experienced pilot, arrived in Germany, the four-engined York aircraft had settled at Wunsdorf and the twin engined Dakotas at Fassberg.

He visited first the Dakotas. His method was to fly with any crew on their last trip of the day or night before going off duty. The spirit and morale, as would be expected, were high. But despite this he soon discovered signs of fatigue, often severe. As well as the large number of sorties in a session of duty, sometimes four times to Berlin and back, there was the inevitable overcrowding and irregular meal-times. He described to me an occasion in the early days when he was flying second pilot to a Dakota captain. He had joined the crew at Fassberg for their last trip of four that day. The weather was poor and the flying mostly on instruments. He noted the usual signs of a tired pilot, over correction of the controls and a less meticulous keeping to the course. They landed safely at Gatow airport in Berlin and after the aircraft had been unloaded, taxied out to take off for Fassberg and long overdue rest. The doctor flew the aircraft back and they had not been airborne for more than a few minutes when he realised that the rest of the crew were asleep. When they had landed, taxied in and switched off the engines the captain released his safety harness and stood up and then at once sat down again. This happened three times. On enquiry he told the doctor that every time he stood 'everything went black.' This was nothing more or less than sheer fatigue occasioned by the will to carry on a job that had to be done.

At the outbreak of the 'cold war' on Berlin in the form of a blockade by the Russians, I had been at Transport Command for less than a year. As flying personnel Medical Officer on the P.M.O.'s staff my duties were to report on aircrew conditions in the air and on the ground and where necessary to make recommendations for their improvement. I had made several trips down the routes to the Middle and Far East in the Yorks. I always managed to fly as second pilot in order to be completely associated with the crew as a working member. In this way I felt that I could best experience the trials and irritations of route flying and that my reports would be of more value than the remote and impartial observations of a visiting staff officer.

About a month after the start of 'Operation Plainfare' when the greater proportion of transport crews and aircraft had moved to Germany, the Air Officer Commanding in Chief, Air Marshal Sir Brian Baker, sent me to fly on the airlift. I had been itching to go from the start and a very few hours later I was on board an aircraft for Germany. Thinking over the task on the journey I thought that I would stick to my method of working on the routes and when I got to

Fassberg, the Dakota base, would join any crew willing to have me. I had flown Dakotas in the Middle East and so would probably be acceptable as a second pilot. In any case I was far less experienced as a pilot or in aviation medicine than the Wing Commander from the 'Lab' and might well miss what I was looking for, or worse still, overemphasise unimportant details. It seemed the best way for me to assess fatigue was to see how tired I got and then add on some more for the responsibility that was the Captain's.

Soon after arriving at Fassberg I ran into a squadron leader who was at school with me. After I had explained my job and how I would like to do it, he kindly agreed that I should fly as his second pilot for the next two or three weeks. I reported to the Station Commander and the Wing Commander in charge of flying, who, to my relief, agreed to my plan. I had thought they might insist on my making a routine staff visit and reporting through the usual channels. From my point of view this would be useless if I were to experience fully the work of the Dakota crews and try to assess the degree of fatigue that existed. The plan of operation at that time was for the Dakotas to work on a cycle of three days. On the first day two trips were made, the second four trips, and on the third three trips. This cycle was repeated with a day off as often as could be managed. The Dakota is a reliable and fairly simple aircraft to fly and in itself did not constitute a major factor in fatigue. I came to the conclusion after two or three weeks at Fassberg that it was mostly conditions on the ground that presented the most serious problem. It was certain that the crews were on occasions extremely tired. It was not just the flying but the length of the day spent at the flight waiting for loaded aircraft or at Gatow Airfield near Berlin waiting for them to be unloaded.

Another major factor was the unsuitability of the food. On the airfields at Fassberg and Gatow, buffets had been set up to supply tea, cakes and buns. On the face of it this would seem to be an adequate provision for the wait between flights. But in the early days tea and buns more often than not made up the main part of the day's food, for the flying times never seemed to fit in with the routine of meals in the messes. It was quite usual to manage only one main meal in the mess, perhaps breakfast first thing, or dinner at night if your particular crew finished the day's flying before the meal was over in the mess. On the four-trip day one nearly always left the mess before breakfast and returned long after dinner was over, and so the day's sustenance inevitably consisted of innumerable cups of tea and a succession of rather dull buns. Tea and buns are all right in their place and time, but as a stable diet they are apt to pall. As day succeeded day, the crews lost their appetite and indeed weight, and quite naturally were more tired on this rigorous job than if their vigour had been supported by some good red meat. Some time later, in my eagerness to emphasise to a very senior officer the need for sufficient protein for the crews, I inadvertently coined an alliterative and rather vulgar phrase to the effect that 'you can't fight, fly and "flirt" on buns'! Fortunately, he roared with laughter and my unintended impertinence went unrebuked.

It was nevertheless a very real problem. Strict rationing was still in force and meat was very scarce and insufficient even for a supply of pies or sausages at the canteens. Many of the crews complained of serious weight loss after quite a short time. The problem was overcome in two ways. First the meal time hours were extended in the messes and then some time later canteens were set up that provided hot meals at all times of the day and night. These made a tremendous difference to the well-being of the crews and was a major help in the prevention of fatigue.

The Officers' and Sergeants' messes were typical of those of a peacetime German station. They were spacious and the facilities were good, but with the sudden increase in population the sleeping quarters were overcrowded to the extent that most rest and sleep was disturbed by crews retiring and getting up to fly at different times. It was rarely possible for a crew to have a room to themselves, since only one of a crew might be an officer and the rest N.C.O's. One facility that was a great boon on this station was the excellent station swimming pool. There was no time for organised games but a quick swim did much to provide relaxation and exercise.

After about three weeks on Dakotas I returned to England to put in my report to Headquarters Transport Command. I received permission to return straight away to Germany where I was anxious to get to Wunsdorf and see for myself how the York crews were faring. One problem that had impressed me strongly at Fassberg was the difficulty and complexity of working out a satisfactory flying programme. While aiming at the maximum lift it had to take into consideration weather, unserviceability, and available crews, and at the same time try to allow sufficient rest and time off. I remember particularly an Operations Room Flight Lieutenant at Fassberg who appeared never to be off duty. He spent hours working out the schedules and rotas and yet never seemed to lose patience or enthusiasm despite all the thousand and one things that can go wrong when running such an intensive operation. I watched his work very closely, whenever I was not flying, for it seemed to me that the correct planning of these schedules over a given time was paramount if crews were not to be seriously and perhaps dangerously overworked.

Arriving at Wunsdorf I was again lucky. Walking into the Operations block the first person I met was a young squadron leader with whom I made my first trip down the transport routes to Singapore. He took me into the operations' room after I had explained that my object was to select a crew for me to join. He was Operations' Officer for the day and allowed me to pick a crew from the list with a pin. As it turned out, they were on the day shift but I would meet them in the mess that evening. Before taking my kit up to the Officers' mess I had a good look around the Operations' block, aircraft standings, and the loading and check points. The mess was attractive and well proportioned but, as at Fassberg, sleeping accommodation was at a premium. A large percentage of the aircrew officers were living in attics which had been turned into dormitories. The furniture was sparse and consisted of an airman's bed each and very little else. Downstairs the more fortunate were crowded four or five into a bedroom usually meant for one. Despite the muddle and discomfort and the mediocre food, morale was high and everyone seemed cheerful. After all, we reminded each other, living conditions down the routes were scarcely luxurious. At least there was an all important job to do and for the first time nearly all the York crews of Transport Command were gathered together on one station.

After dinner that night the squadron leader and I went down to the Bierkeller type of bar to be found in all German messes. I was a little apprehensive of meeting the crew with whom I hoped to fly. This may sound absurd, but flying doctors are not always readily accepted by aircrew, for there is often a suspicion that one might be prying and would find something which would, if it concerned their health, prevent them from flying. My apprehension in this case was justified. The greeting from my proposed captain was unsmiling and curt. He was a short, stocky Canadian flight lieutenant with a morose and brooding expression. He reminded me of the late John Garfield in one of his tougher and sterner roles in one of Hollywood's productions.

The squadron leader left us and conversation flagged. He offered me a drink and after a pause supposed that I had come to test their reactions. Sensing his antipathy I replied quickly that on the contrary I had come to test mine. His expression lightened and I seized the opportunity to offer him a drink. He returned to the subject and asked me to explain how I proposed to set about it. I told him of my belief that the best way of examining aircrew working conditions and assessing the amount of fatigue that existed was to do the job oneself. To my relief his interest grew and in a very short time we were all friendliness and Christian names. He briefed me on the general set up and what my duties would be as his second pilot. He asked what flying I had done. I admitted that I had trained in fighters but had done a certain amount of transport flying in the Middle East in Dakotas, Venturas and Lodestars though I had only had a few trips on Yorks, down the routes. About ten o'clock he suggested bed as we were to be airborne for our first trip next day at 0730 hours. As we parted he said he expected that I would like to do some flying. Thinking that he meant taking over from him in the air, I agreed eagerly and thought no more about it until the next morning.

As we taxied along the perimeter track at 0728 hours the next day I gazed out of the second pilot's window at the scene of almost feverish activity. York aircraft were everywhere, being serviced by airmen and loaded by soldiers and German civilians. There was one aircraft already lined up on the runway waiting for permission from the control tower to take off. After a final run up of the four Merlin engines and our final checks we turned on to the runway. I was still staring rather vacantly out of the window when an incisive Canadian voice cut across my thoughts. 'Come on, get on with it, we shan't get to Berlin sitting around like this.' I stared at the captain and it suddenly dawned on me that I was supposed to do the take off. I thought back to his parting remark that night before and realised he meant that if I wanted my reactions tested now was the time to start. He folded his arms and looked out at the side, indicating all too clearly that it was all mine. Refusing the flight engineer's offer of help, I seized the stick and the four throttles, put my feet on the rudder bars and released the brakes. As we rolled forward I kept her straight with engine until the rudder became effective. At a hundred knots I eased back the stick and off she came. Remembering the drill, I held the aircraft down until we had safety speed of 110 knots. Undercarriage and flaps up, we climbed away to our quadrantal height of 2,000 feet. No comment from the first pilot's seat. Anyhow, I had accepted the challenge and, if not in a polished manner, had managed my first four-engine take off with seven tons of coal in the back.

The skipper wisely took over for the landing at Gatow and after the usual tea and buns while waiting for the aircraft to be unloaded we again taxied out to the runway. This time I took off with the nonchalant air of an experienced York pilot. It seemed to me that we fairly shot into the air without that coal on board. The hour's flight back was uneventful and as we approached Wunsdorf we received landing instructions from control. 'It's O.K.,' said the skipper, 'You can go straight in.' He meant, of course, that we could land straight ahead instead of making a circuit. Thoughtfully preparing now for my first four engined landing I muttered a reply. 'Go straight in! That's probably exactly what we will do.' The rest of the crew, a Flying Officer navigator and two N.C.O.'s, ragged me unmercifully on the approach. Screams of mock terror implored the skipper to take the thing away from me before I broke it! The captain's face remained impassive. I eased back the throttles and rounded out the glide and, more to my surprise than anyone's, achieved a smooth tail down 'wheeler,' a text book landing for the type. As I taxied in, the captain's morose expression broke into a charming grin as he said, 'Bang on!' I was 'in,' and I only mention the incident at some length once again to emphasise that to know and work successfully for aircrew a doctor must fly with them.

The operational plan for the Yorks at that time worked in a cycle of about two weeks. It started off with three flights a day for four days, followed by twenty-four hours off, then three flights a night for four nights, a further twenty-four hours off, and a final four days of three flights each. Though this only meant about six hours flying in a day or night, the whole work session with its inevitable waiting, briefing and sometimes unserviceable aircraft was rarely less than twelve hours and often as much as fourteen. At the best it was a seventy hour week and at the worst well over eighty. Even had the living conditions been ideal, such a schedule would have soon resulted in severe fatigue. As it was, with the overcrowding, disturbed sleep periods, and indifferent feeding, the position was fairly grim. This cycle of operations was repeated after a 'forty-eight' and only a few were fortunate to return to England for a few days when aircraft were taken back for major servicing.

A most important factor I remember particularly was the incessant noise. One quickly got used to aircraft running up but personally I never managed to ignore the whining gears of the Army three ton lorries which screeched past the sleeping quarters with monotonous regularity every two minutes of every day and night. Trying to sleep during the day was the most difficult. In addition to the normal daytime bustle of an officers' mess there was the increase in general traffic and activity on the station and the constant arrival and departure of crews coming from and going on duty. I was certain that a high proportion of crews were starting their night's work with as little as three or four hours real sleep out of the eight they should have been getting.

In the early stages of the airlift the burden fell mostly on the pilot for the navigation over a short trip of an hour was minimal. The second pilot could relieve him in the air, but as winter approached and the weather deteriorated, the captain must make all take offs and landings himself. It sometimes occurred that a pilot might have to make all his approaches on instruments with a cloud base often as low as 150 feet. During the second two weeks' schedule that I had been flying with this crew I remember an experience similar to that of the wing commander from the 'Lab.'

We were on the last of our four night sessions and glad of it, for even our resilient Canadian skipper was beginning to show definite signs of weariness. The weather was poor to start with, though the visibility was reasonable. The night's flying turned out to be just the 'last straw.' On our first take off, again with seven tons of coal up, the port outer engine cut just as we were airborne. The pilot held her down and the air speed needle crept slowly to safety flying speed and suddenly the coughing engine picked up and the revolutions remained steady. We flew on towards Gatow with the weather worsening all the time. We landed at Berlin in a cold sleety rain and a high wind. Arriving back at Wunsdorf we found that the weather was as bad as at Gatow. Such was the pattern for the night's flying with an instrument approach and bad visibility landing for the captain at either end.

I must confess that as we taxied out for the third and last take off from Gatow I was exhausted. The captain's normally stern face was even more grim and set and he looked pale and hollow-eyed in the dim light of the cockpit. He turned to me. Would I like to take off and fly it back? I was on the point of refusing on the grounds of combined inexperience and fatigue when it occurred to me that this was a unique opportunity to experience a part of what he had been through that night. I had been able to help out with some of the flying in the air but of course I was not capable of taking my share of the bad weather landings. I agreed as brightly as I could and took over controls while we were taxying. We turned on to the runway, lined up and called up for permission to take off. It was raining hard and low cloud was scurrying before the gusty wind as we rolled down the perforated steel plate runway. As I pulled her off the runway I caught sight out of the corner of my eye of the skipper, his head slumped forward on his chest. He must have fallen asleep before we left the ground. Although I think I had proved moderately reliable as a second pilot with an occasional landing and take off in good conditions, it is a measure of his extreme fatigue that he was too tired to check my take off. A few minutes later all the crew were asleep.

It was a wretched journey back. Flying at 1,000 feet the aircraft rocked and bumped in the turbulence. I remember cursing the instrument panel which must have had something wrong with its suspension for it wobbled like a jelly and it was hard to keep the instruments in focus. A few minutes before Wunsdorf I woke the pilot up. Even after those few minutes rest he seemed refreshed and taking over he made a good approach and landing with rain falling from a cloud base of less than two hundred feet.

It is strange that what remains most clearly in my memory of that night is an amusing vagary of the captain's character. Under normal circumstances he had that splendid

Canadian fluency in his use of the shorter and more unattractive expletives, which would have done justice to the most experienced Thames waterman, but under stress, such as an engine cutting on take off and the taut moments that followed, instead of the expected burst of profanity, all he murmured was a gentle, 'Dear, oh dear, oh dear!'

Conditions on the ground were improving gradually every week. More living accommodation was made available to the crews and it became possible to achieve a reasonable night's rest. Mealtimes were extended in the messes and later the airfield aircrew buffets were able to provide cooked meals at any time. But despite these improvements fatigue remained a serious problem. By this time most of the available York crews and their aircraft were in Germany. Training at Disforth, the Transport O.T.U. had ceased and their instructors and aircraft had also moved over to the Continent. The factors involved presented a pretty problem. The number of crews could not be increased and at one and a half crews to each aircraft was as low as it could be. A higher and higher daily load into Berlin was the aim. No one could say, even at the highest level, how long the operation would continue. The cycle of operations and daily schedules were already producing severe fatigue in even the most experienced crews. To continue as we were, would inevitably mean a mounting accident rate with its attendant fatalities, which, since we were not at war, could not be justified on the ground of expendability.

The problem was how to strike a balance between the urgency of the task, an indefinite time scale and limited human resources. The operations' room staff spent endless hours trying to work out a satisfactory plan which, while achieving the object of maximum airlift would allow sufficient rest for the crews to carry on indefinitely. The more I thought about it the plainer two main points became to me. Firstly, that we only had a limited amount of human material with all its motivations, energy and resolve, and, secondly, that no sort of juggling on paper with flying programmes would magically increase that potential or extend its breaking point. It seemed to me that with the amount of fatigue that already existed the time was dangerously near when the operation might come to a grinding halt through the sheer inability of the fatigued crews to carry on. It was quite certain that the crews themselves would never give in and in that alone were a hazard to themselves.

The answer was obvious but unpalatable. The daily stint was too much and must be reduced even though it incurred the political danger of a decreased lift. One fatal accident had already occurred when a York taking off on the third trip at night had crashed and all the crew were killed. The port outer engine had cut on take off. The aircraft was seen to climb to about 800 feet and then turn sharply to port and dive into the ground. It is problematical whether fatigue had anything to do with it, but a suspicion lurked, in view of the 4,000 hours experience of the pilot and the fact that he must have had safety flying speed and had reached 800 feet. Rightly or wrongly it niggled at the back of my mind. Another incident fortuitously strengthened my resolve that the only recommendation I could make in my report would be a reduction of working hours.

One night on the 'Graveyard Watch,' as the night session was nicknamed, probably the two most skilful and experienced pilots on the station independently reported to the Operations' Officer that they were not doing their third trip. The value and importance of this happening was that both officers' morale and integrity were of the highest order and were backed by their equally splendid war record. It was exactly the evidence I needed for my recommendations. If two men of their calibre had wisely and sensibly packed in, then I knew I was not over-emphasising the severity of the problem. Further, though they in their position could without slight take such action, it would not be nearly so easy for a less experienced and more junior pilot. And that was the most worrying part to me, for one must always consider the average man's ability in a problem of this kind.

Soon after this I left again for England to report to Transport Command. In the Commander-in-Chief's office I posed the problem to him and nerved myself to make the recommendation that I considered inevitable: that if 'Operation Plainfare' was to be of an indefinite length, that if no more crews were available then the only possible action was the removal of the third trip from the day or night flying schedule. After he had considered the position from all angles, listened to everything I had to say, he reached for the 'phone. I think it was the greatest privilege I have had in the service that I was allowed to remain in the office while he spoke to the authorities in Germany. Despite the political significance of a reduced daily lift he arranged quietly and simply for the immediate deletion of the third sorties.

I have mentioned earlier that it was not long before feeding and sleeping arrangements were improved. This combined with the opening of rest camps away from the station and regular periods of leave, speedily resolved the problem of extreme fatigue. The whole transport force maintained an exceptional standard of flying and for the rest of the time that the airlift lasted, I considered morale was of the highest order. From my point of view the operation was a privilege and a unique opportunity to learn much about aircrew that would otherwise have proved difficult and long drawn out under routine peacetime conditions. I have made this the last chapter in the book, not because it is so chronologically, but because the events remain clearest in my mind in my association with aircrew. It has become my firm opinion over the years of flying with and for them that there are none better than the aircrew of the Royal Air Force. My tribute is in essence that of Graeme Anderson, that 'nothing is too good for them' and there is no higher calling in our profession than to strive constantly for their well-being and safety.

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PLATE 14

Above—In the tank at Farnborough. Testing an exposure suit, dinghy and 'Mae West'.

Below—Arctic survival. After sleeping out in a blizzard.

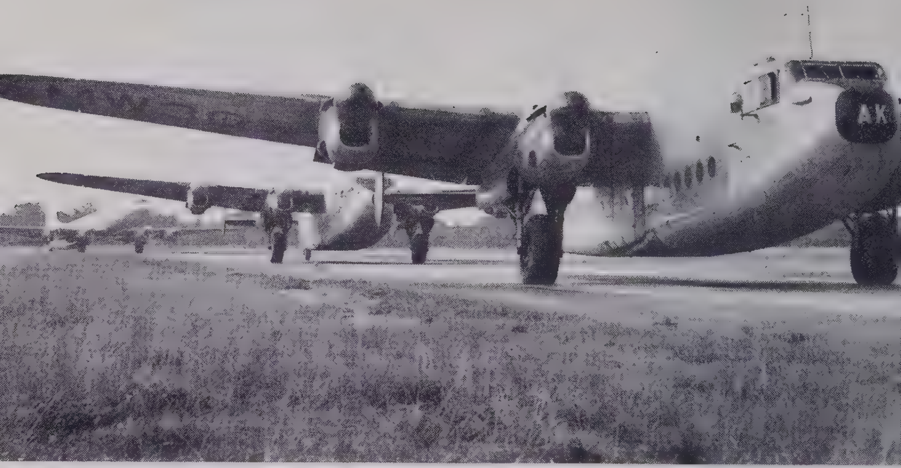

PLATE 15
Day and night on the airlift.
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Below—Yorks in the loading area at night.

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SURGEON AT WAR

Lt.-Col. J. C. Watts

The tremendous emphasis on saving the lives of the wounded in the second World War made the surgeon's life as dangerous as that of the front line soldier. Mobile operating theatres went close to the front line and surgeons took part in the glider-born landings in Normandy. At one time in Normandy Colonel Watts was carrying out major operations within 400 yards of where the men were being wounded.

Colonel Watts is the first British doctor to describe his work as an Army surgical specialist. His range of experience is enormous and he recalls his adventures in the Palestine Rebellion of 1938, Wavell's first desert campaign, the Syrian Campaign and the first advance into Tunisia. After the Salerno landing and his unique employment of skis in the Apennines, the author joined the 6th Airborne Division and took part in the Normandy Landings, the battle of the Bulge against von Rundstedt and the Rhine crossing. Malaya, Java, Palestine and finally Korea complete an impressive and probably unrivalled list of front line engagements.

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DOCTOR'S WIFE IN GREENLAND

Inga Ehrström

Here is a most refreshing and candid story of a Finnish doctor and his young family who spent a year in Greenland. The Swedish-born authoress, Inga Ehrström, and her husband with their two young children settled in the district of Umanak, one of Greenland's remotest colonies, where Dr. Ehrström was to conduct a scientific investigation into the appearance of certain diseases amongst the native population.

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Throughout the siege the unit, including the wounded, was constantly subjected to shelling and mortaring from hills overlooking the town, and to almost unceasing attacks at night by vastly superior numbers of fresh and fanatical Japanese troops. They were short of food, water, ammunition and medical stores, and by the time the relieving force arrived half of them were casualties. Colonel Campbell describes the events of the siege and the deeds of heroism by individuals and small groups alike. Their story is exciting and inspiring and has not previously been told in any widely available form.

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The account of life on the working parties and of the ceaseless war waged between Germans, who thought that prisoners should work, and prisoners who thought they shouldn't (and had no intention of doing so) is told with a wry humour that permeates the whole book. Much of what went on in those working parties may be a little startling to anyone with preconceived ideas on the life of a P.O.W. The accounts of bribery and corruption, the illicit love affairs, and the fantastic subterfuges to get in and out of the camp, make strange reading. The last part of the book, with its grim description of the death march across Czechoslovakia and Germany covers fully an incident that has not been written of in any detail before.

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